COLMEA – (Colóquio Interinstitucional Modelos Estocásticos e Aplicações) UFRJ

13 abril 2022

Mudanças climáticas e objetivos de desenvolvimento sustentáveis: Construindo uma sociedade sustentável

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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

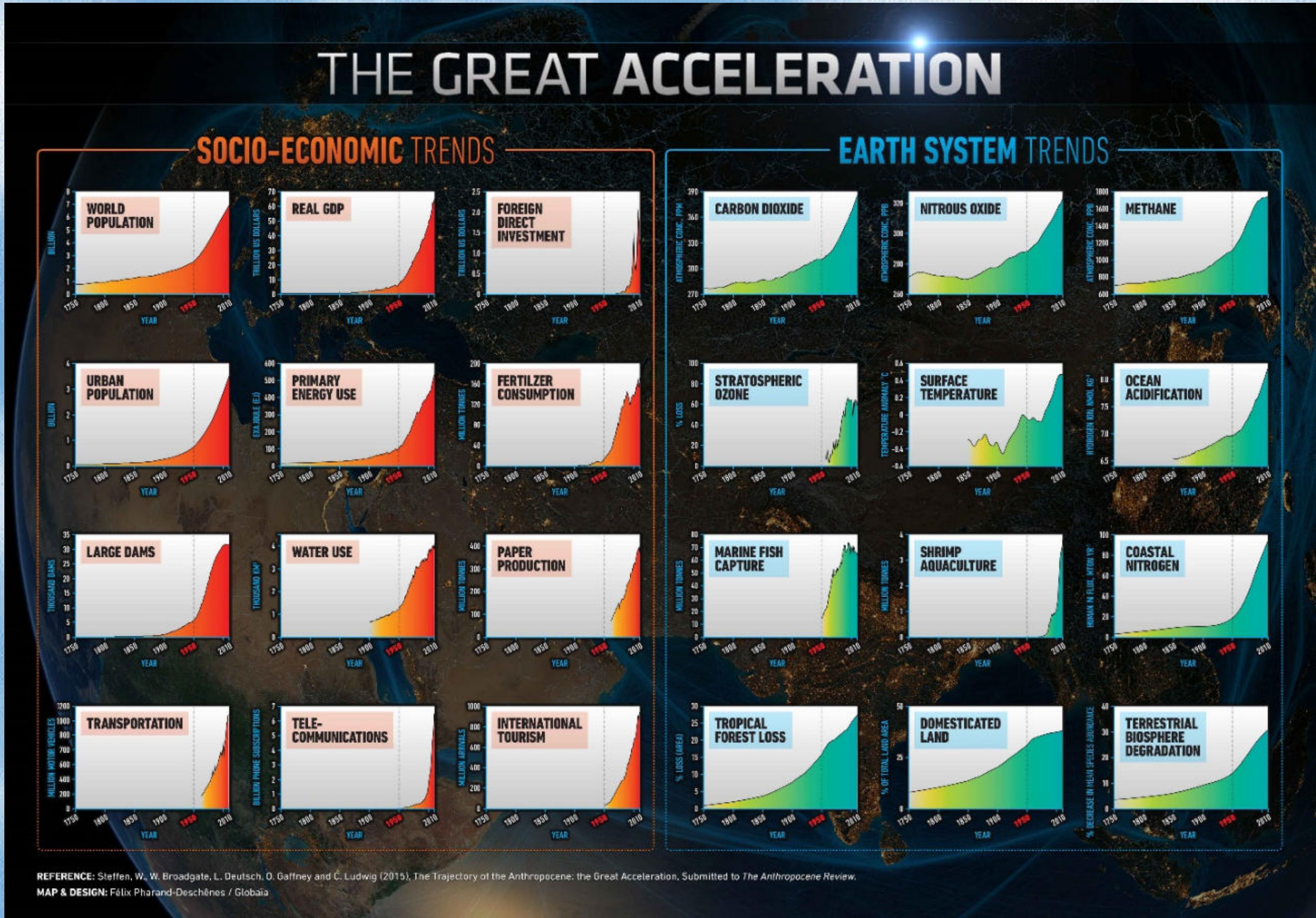
Nosso planeta em mudança, nos compartimentos interligados:

Atmosfera
Criosfera
Biosfera
Geosfera
Hidrosfera

Os limites disciplinares não existem em nosso planeta

A Ciência das mudanças climáticas é muito sólida

Estamos mudando nosso planeta rapidamente e de muitas formas



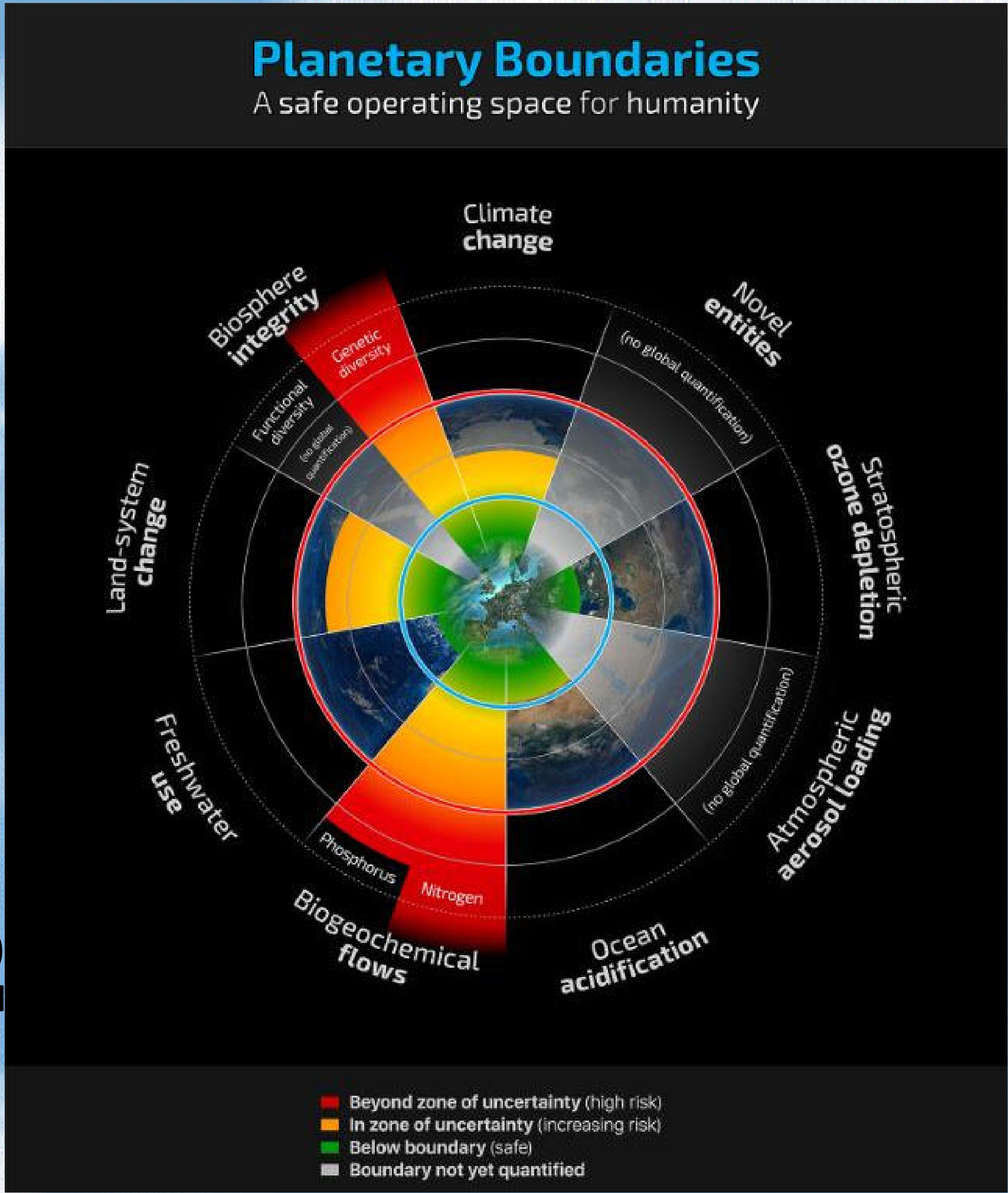
Quais são os impactos destas mudanças?

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

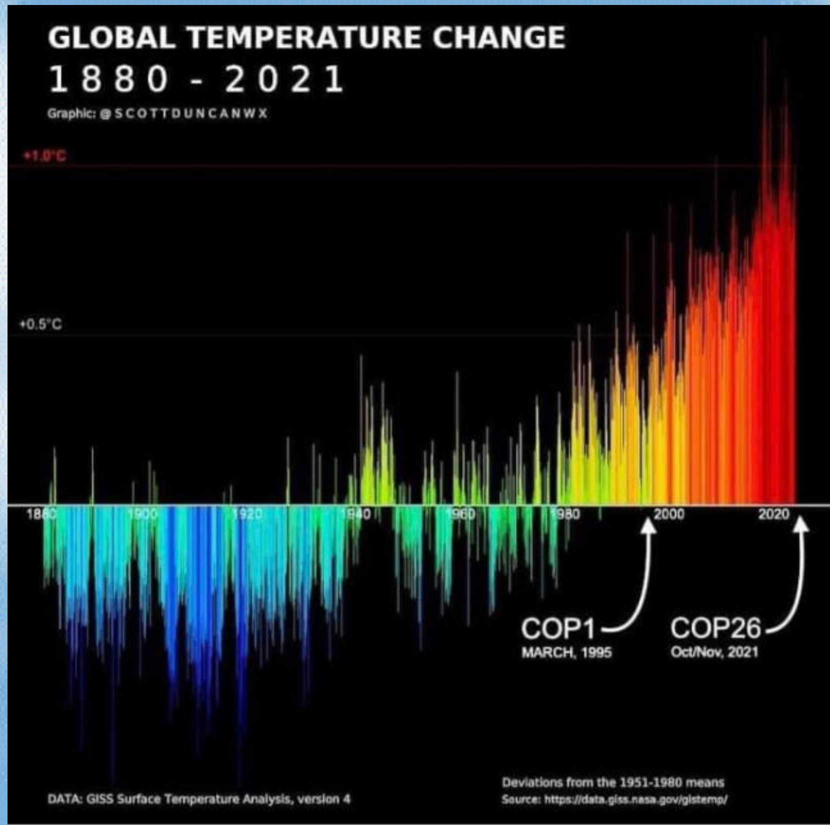
Um pouco de história

Estocolmo United Nations Conference on the Human Environment – ocorreu em 1972, <u>à 50 anos atrás</u>

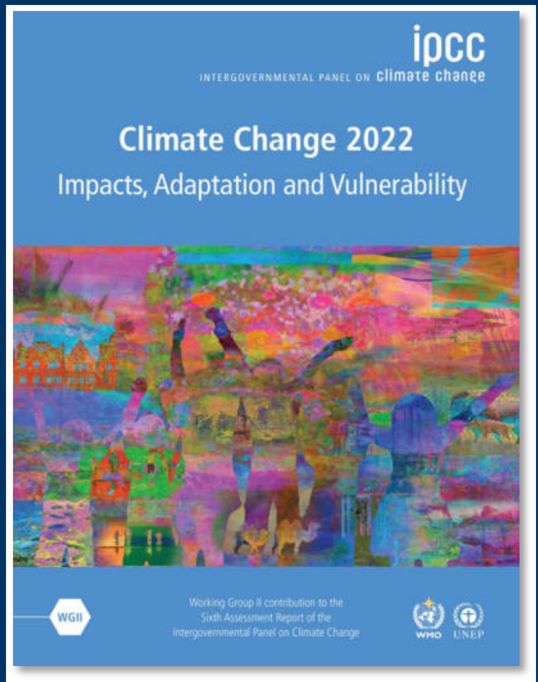
Rio 92: há <u>30 anos atras</u>

Rio+20: há <u>10 anos atras</u>

Estamos na COP-26: <u>em 2___</u>



COP-26: ONU reconhece meio ambiente seguro, limpo e saudável como direito humano



"A evidência científica é inequívoca: mudanças climáticas são uma ameaça ao bem estar humano e à saúde do planeta. Qualquer atraso em uma ação global, coordenada e conjunta, levará a perda de uma breve janela, que se fecha rapidamente, para assegurar um futuro habitável.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

[Credit: Peter John Maridable | Unsplash]

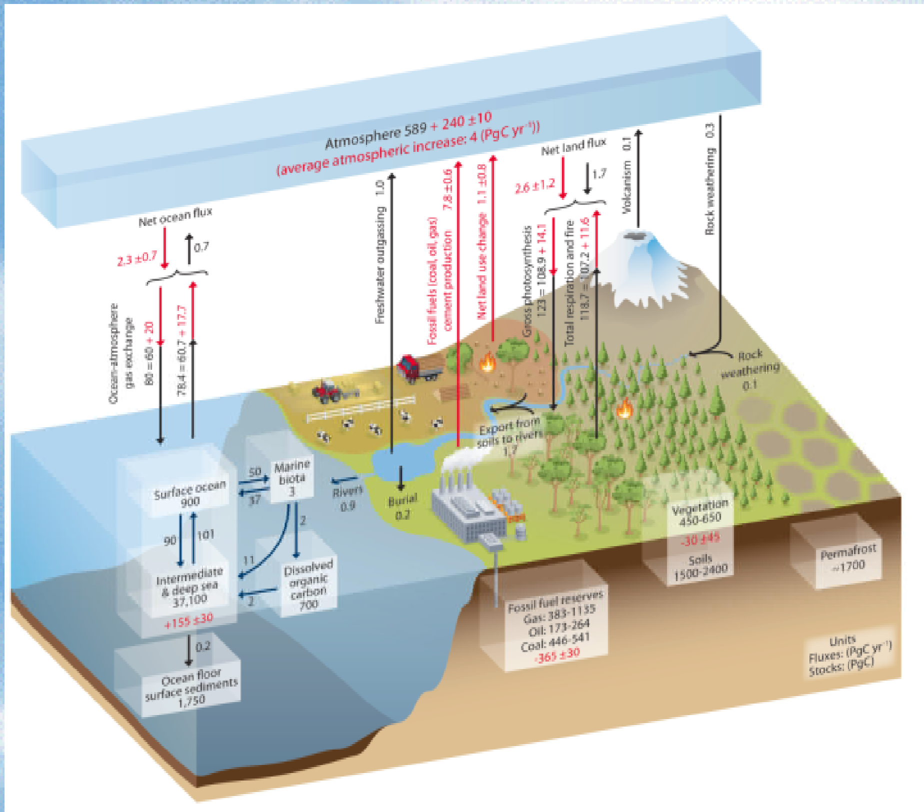
"

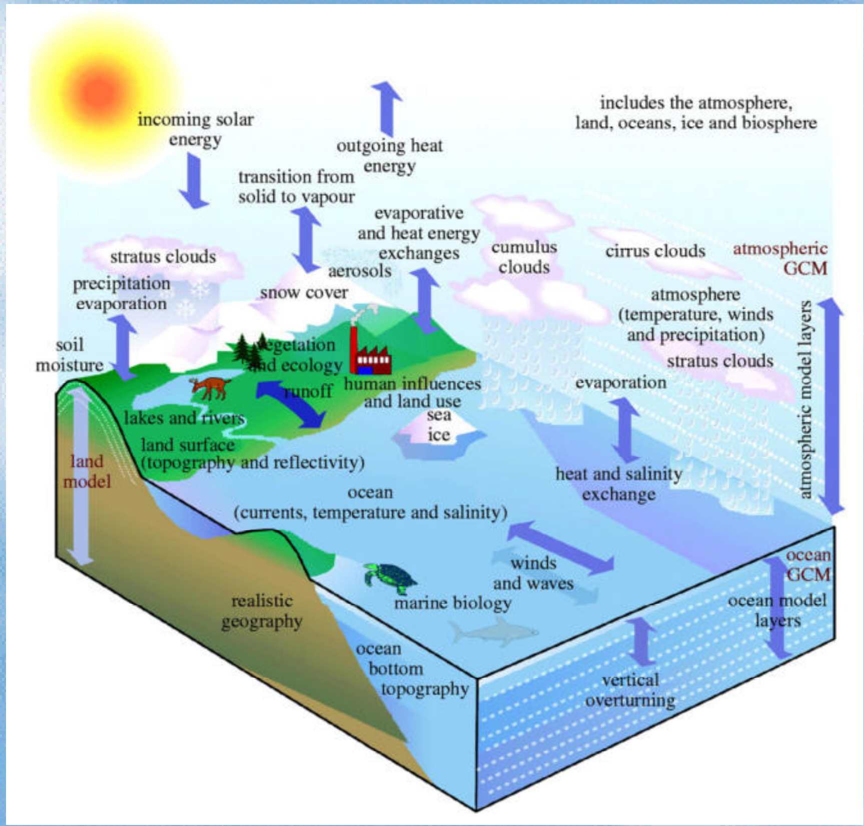
A menos que haja reduções imediatas, rápidas e em grande escala nas emissões de gases de efeito estufa, limitar o aquecimento a 2,0 ° C pode ser impossível.

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

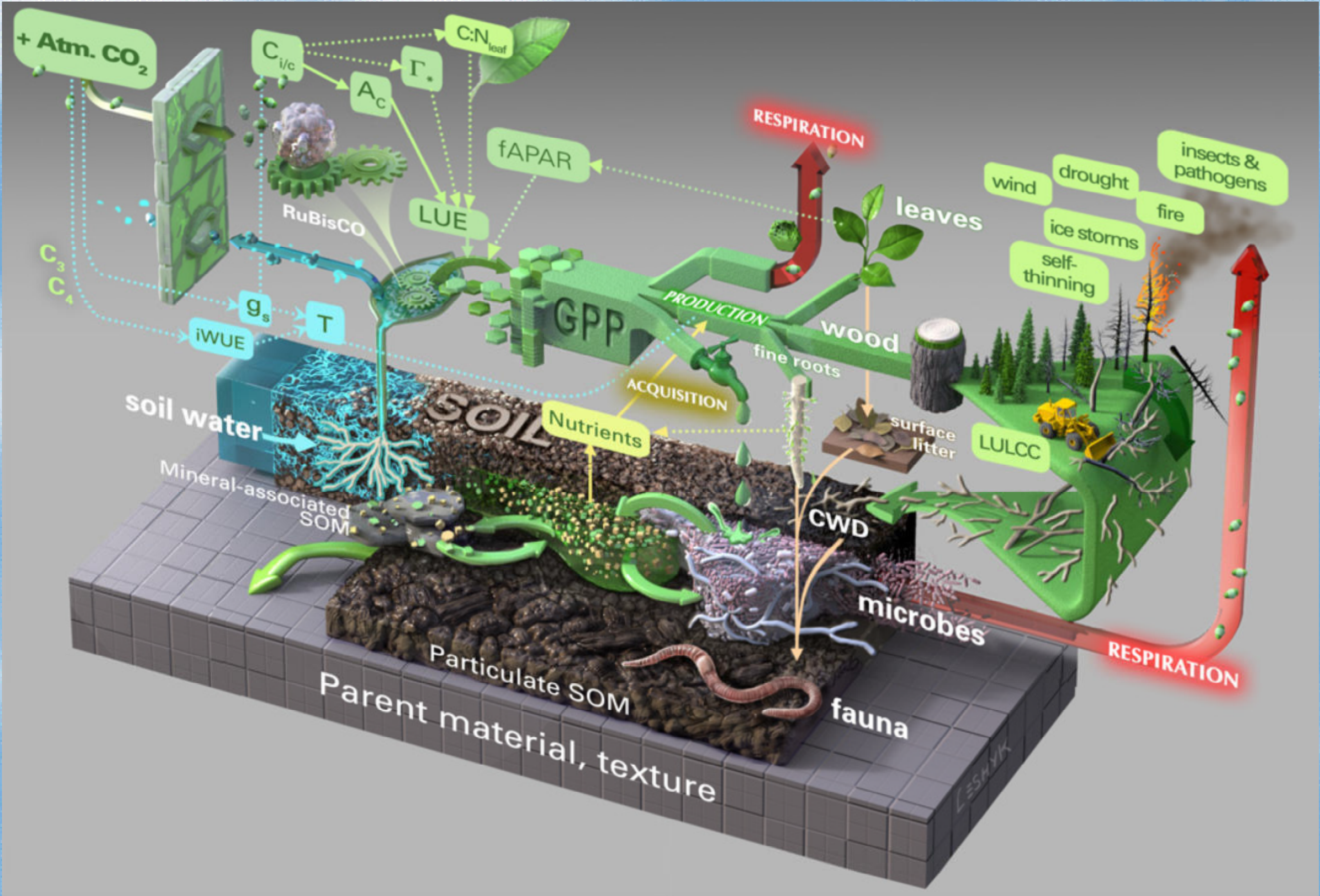
Ciclo global do carbono

O complexo sistema climático terrestre



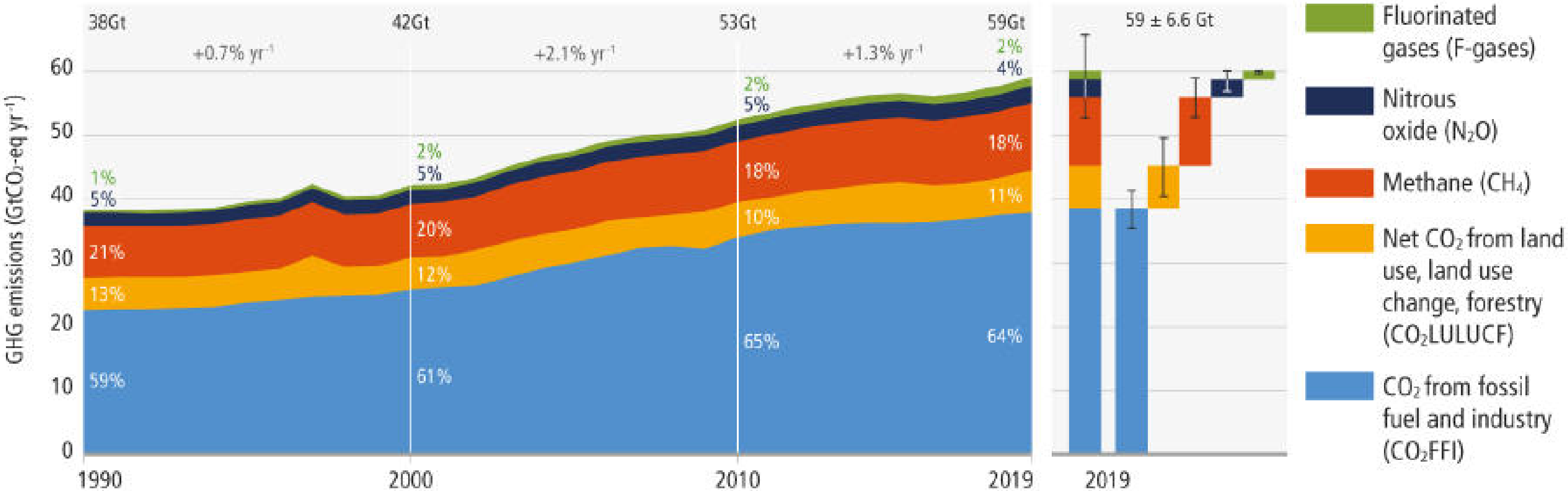


Tropical forests carbon cycle controls: Deforestation, photosynthesis and soil carbon

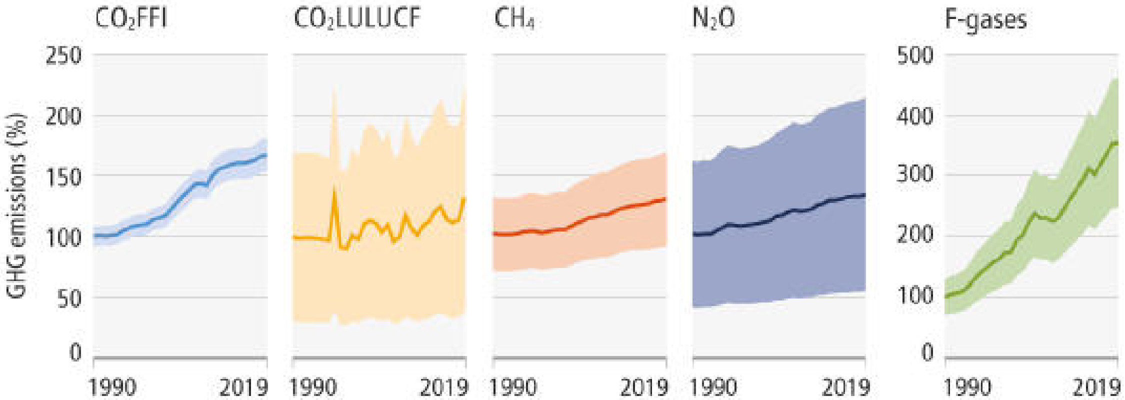


Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.

a. Global net anthropogenic GHG emissions 1990–2019 [6]

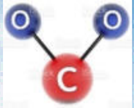


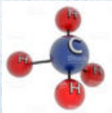
b. Global anthropogenic GHG emissions and uncertainties by gas – relative to 1990



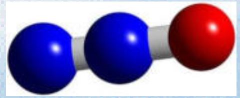
	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

The solid line indicates central estimate of emissions trends. The shaded area indicates the uncertainty range.

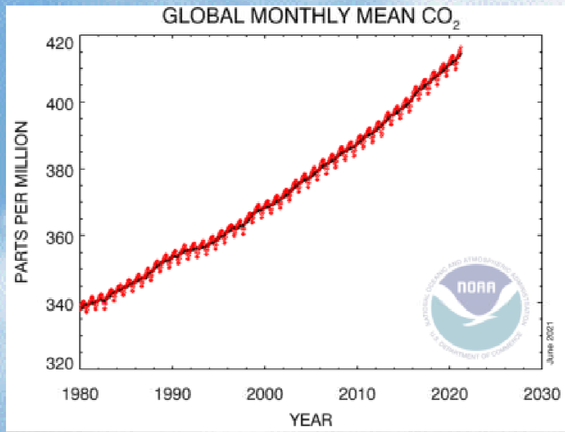


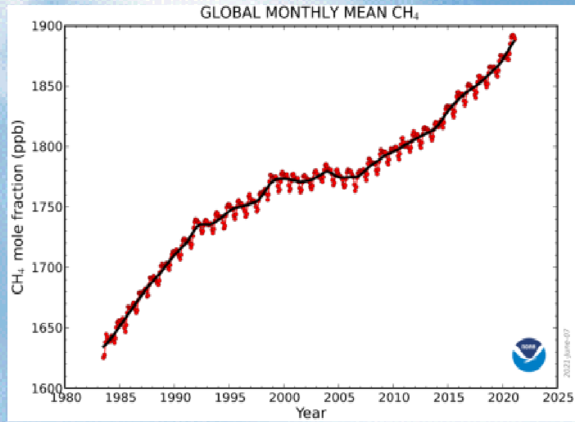


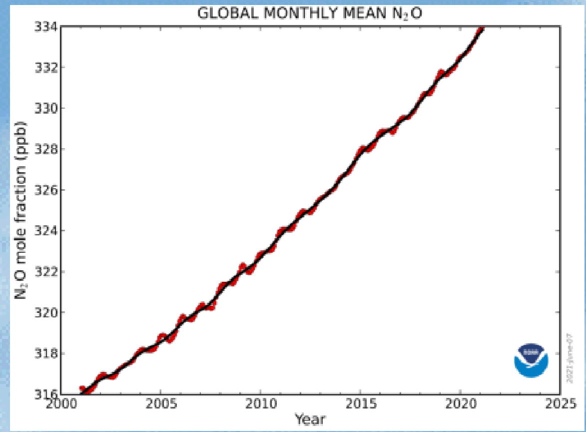
Concentrações de CO_2, CH_4 e N_2O



Aumentos desde 1750: CO_2: 66%, CH_4: 259%, N_2O: 123%

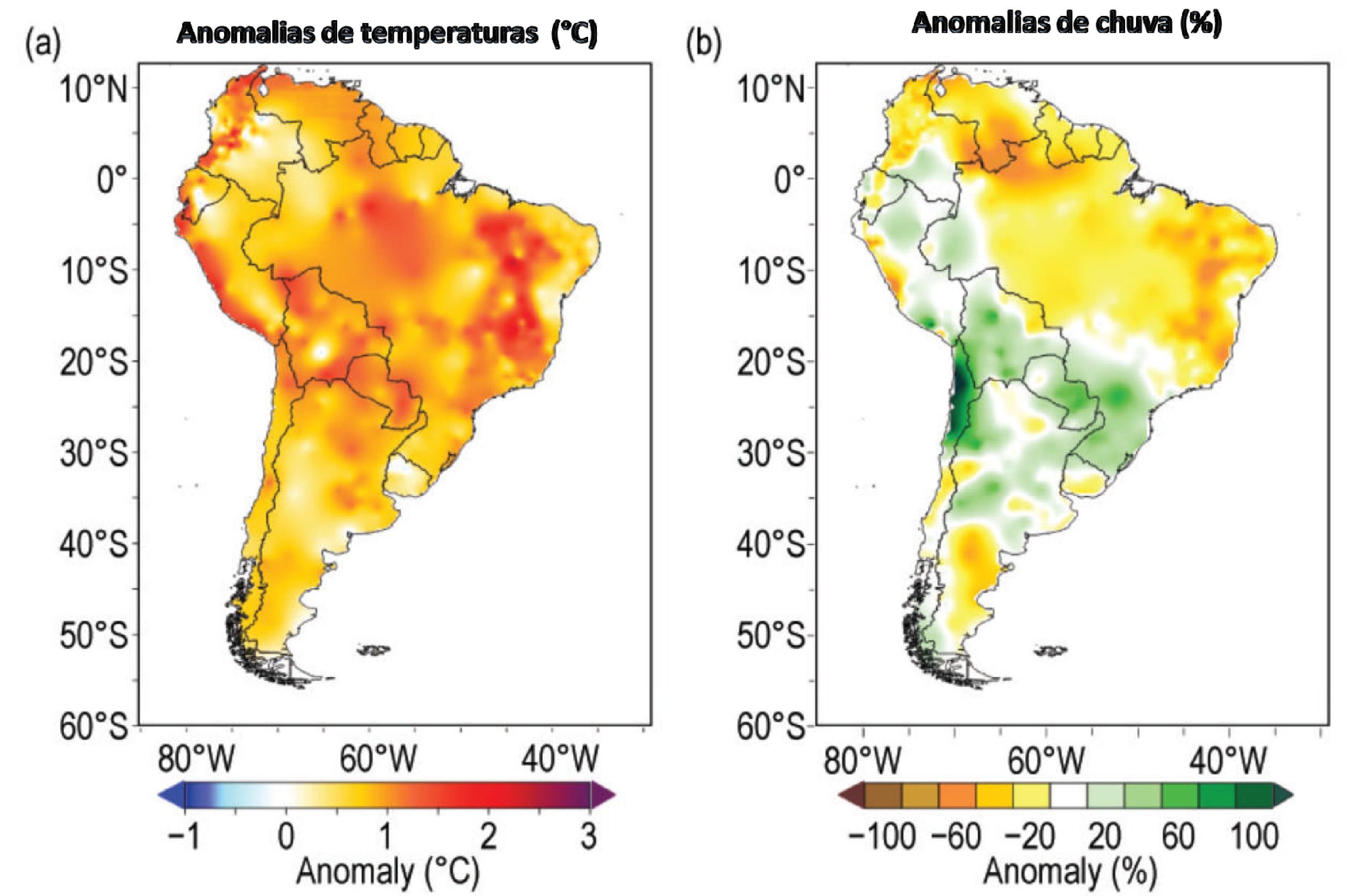






Desmatamento de florestas tropicais: **17% das emissões**
Queima de combustíveis fósseis: **83% das emissões**

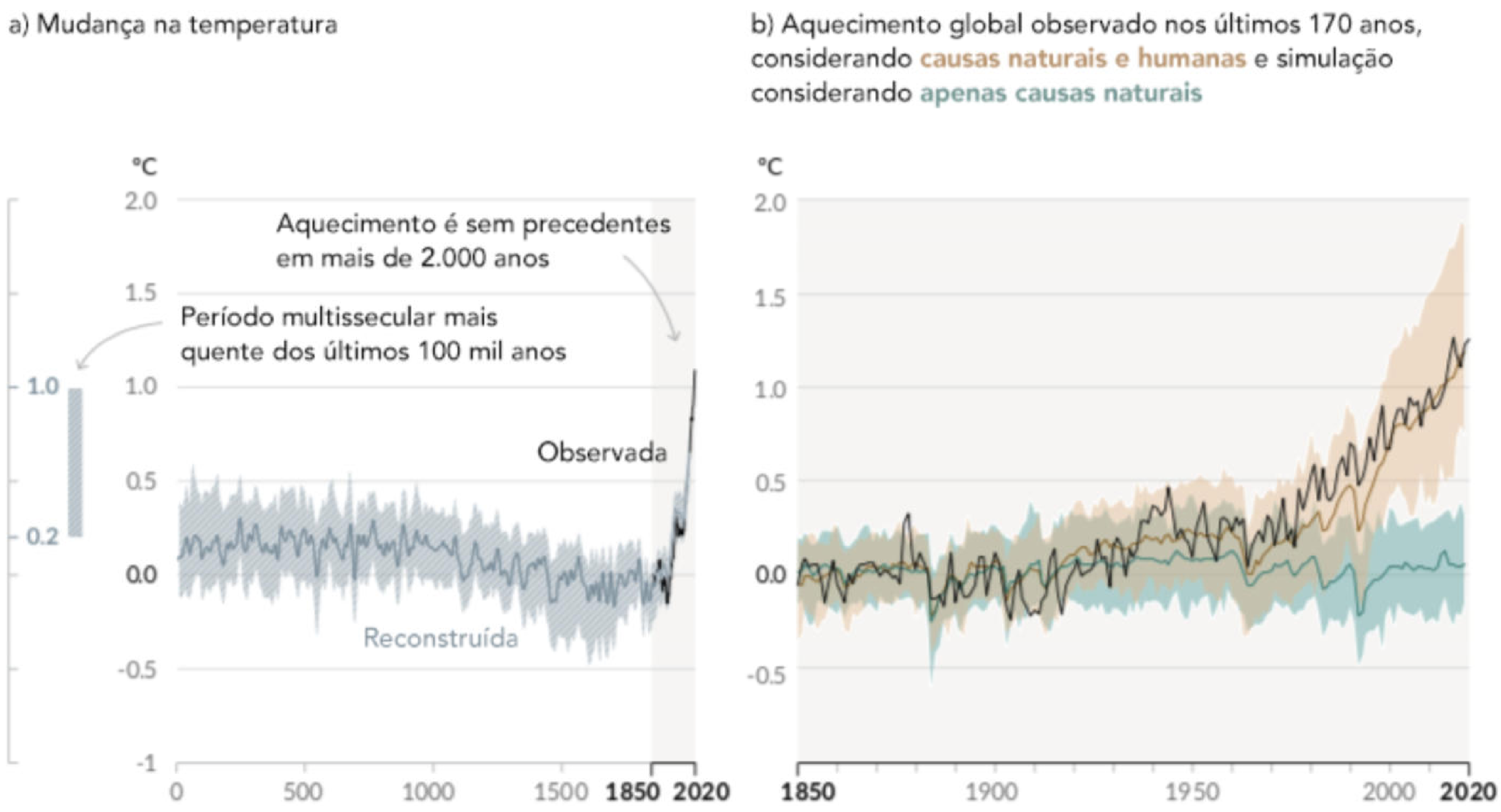
América do Sul: se tornando um continente muito mais quente e mais seco no Brasil tropical



Período de base: 1981–2010.

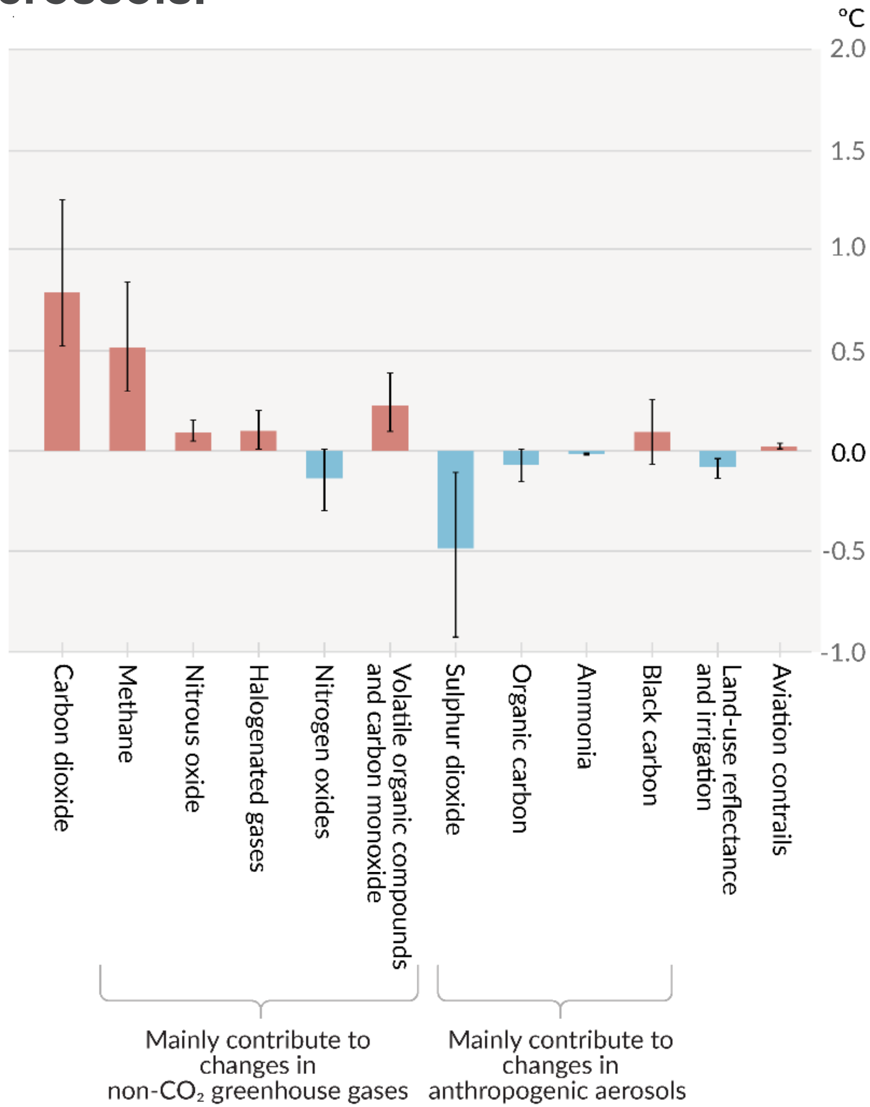
Fonte: State of the Climate in 2015, Bull. Amer. Meteor. Soc., 97 (8), 2016.

As ações humanas tem aquecido o planeta a uma taxa sem precedentes há pelo menos 2.000 anos

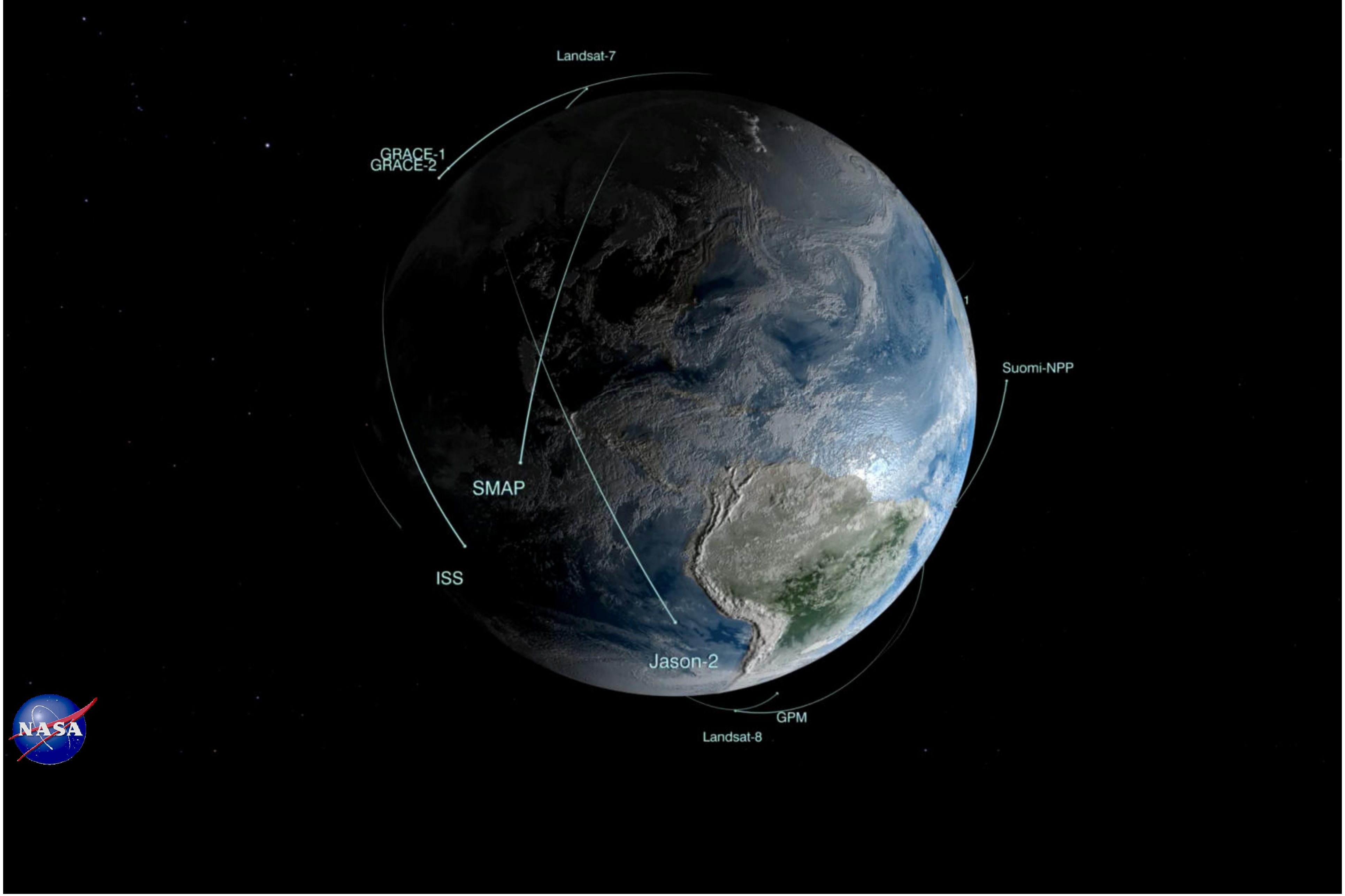


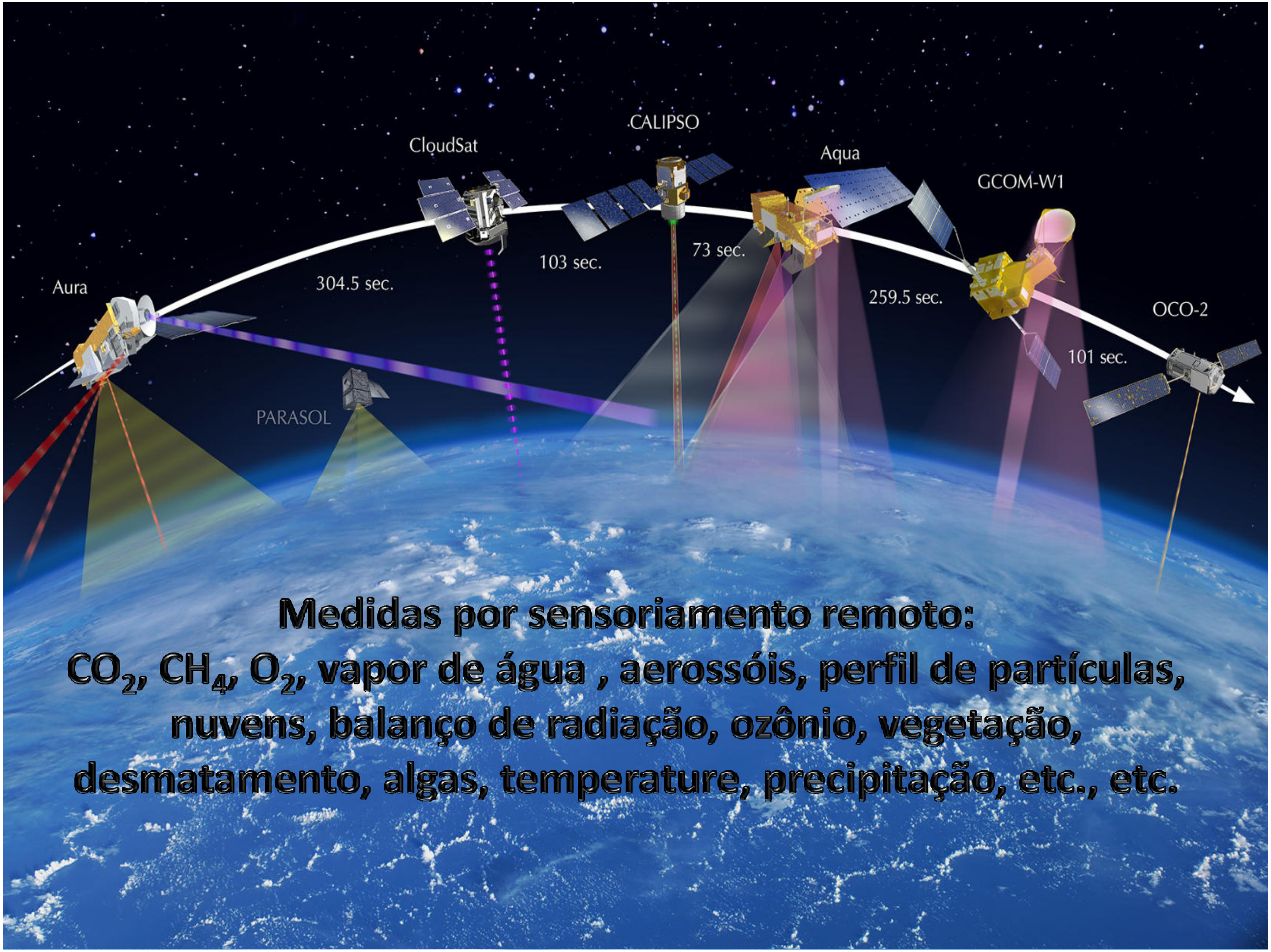
O aquecimento observado é provocado por emissões antropogênicas, com aquecimento associado aos gases de efeito estufa parcialmente mascarado pelo resfriamento provocado pelos aerossóis.

Aerossóis estão <u>mascarando um terço do aquecimento</u> já realizado

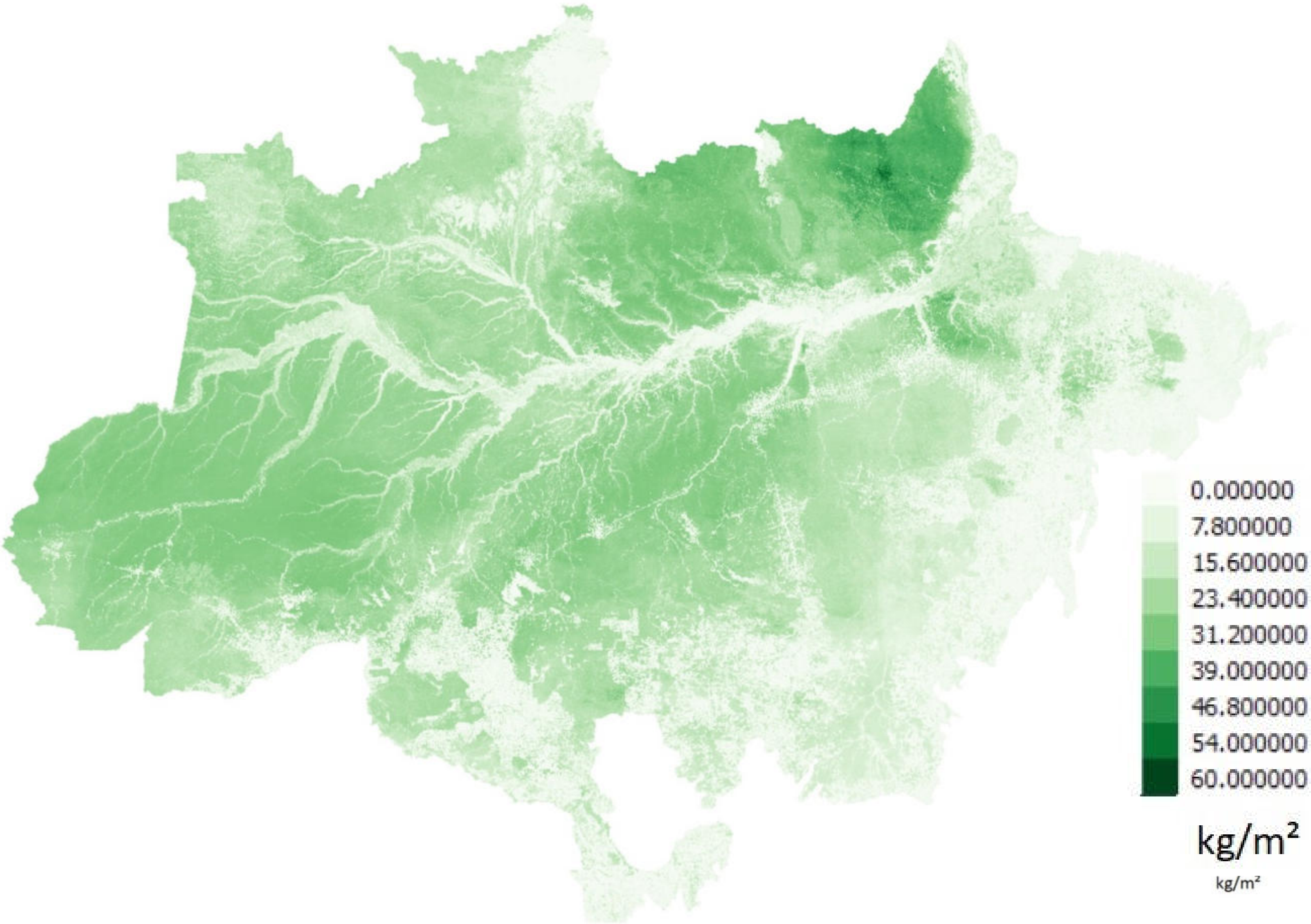


Satélites monitorando ciclo do carbono e variáveis acessórias



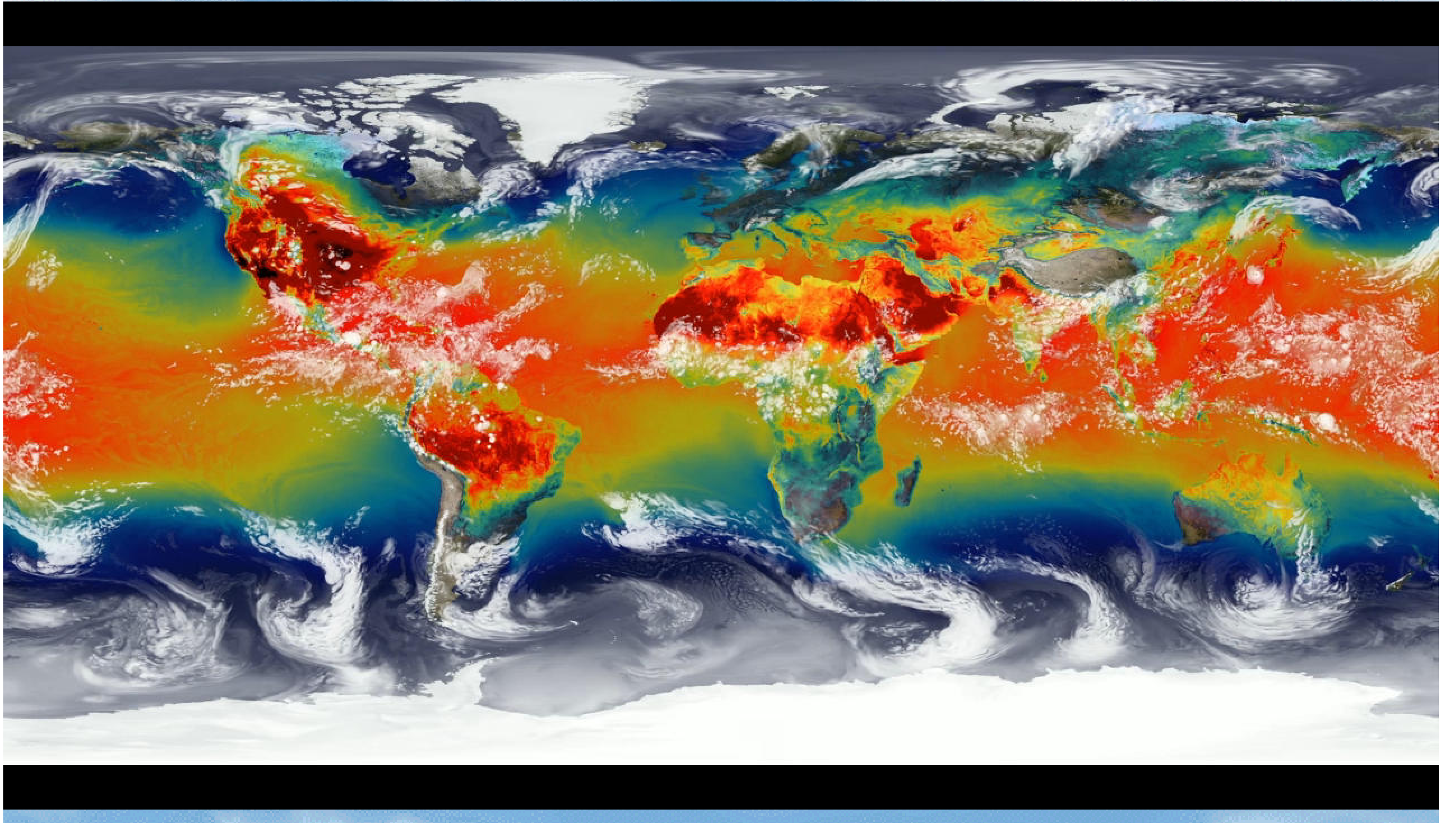

CALIPSO
CloudSat
Aqua
GCOM-W1
Aura
304.5 sec.
103 sec.
73 sec.
259.5 sec.
OCO-2
101 sec.
PARASOL
Medidas por sensoriamento remoto:
CO_2, CH_4, O_2, vapor de água , aerossóis, perfil de partículas, nuvens, balanço de radiação, ozônio, vegetação, desmatamento, algas, temperature, precipitação, etc., etc.

Amazon forest biomass distribution map in Kg/m²



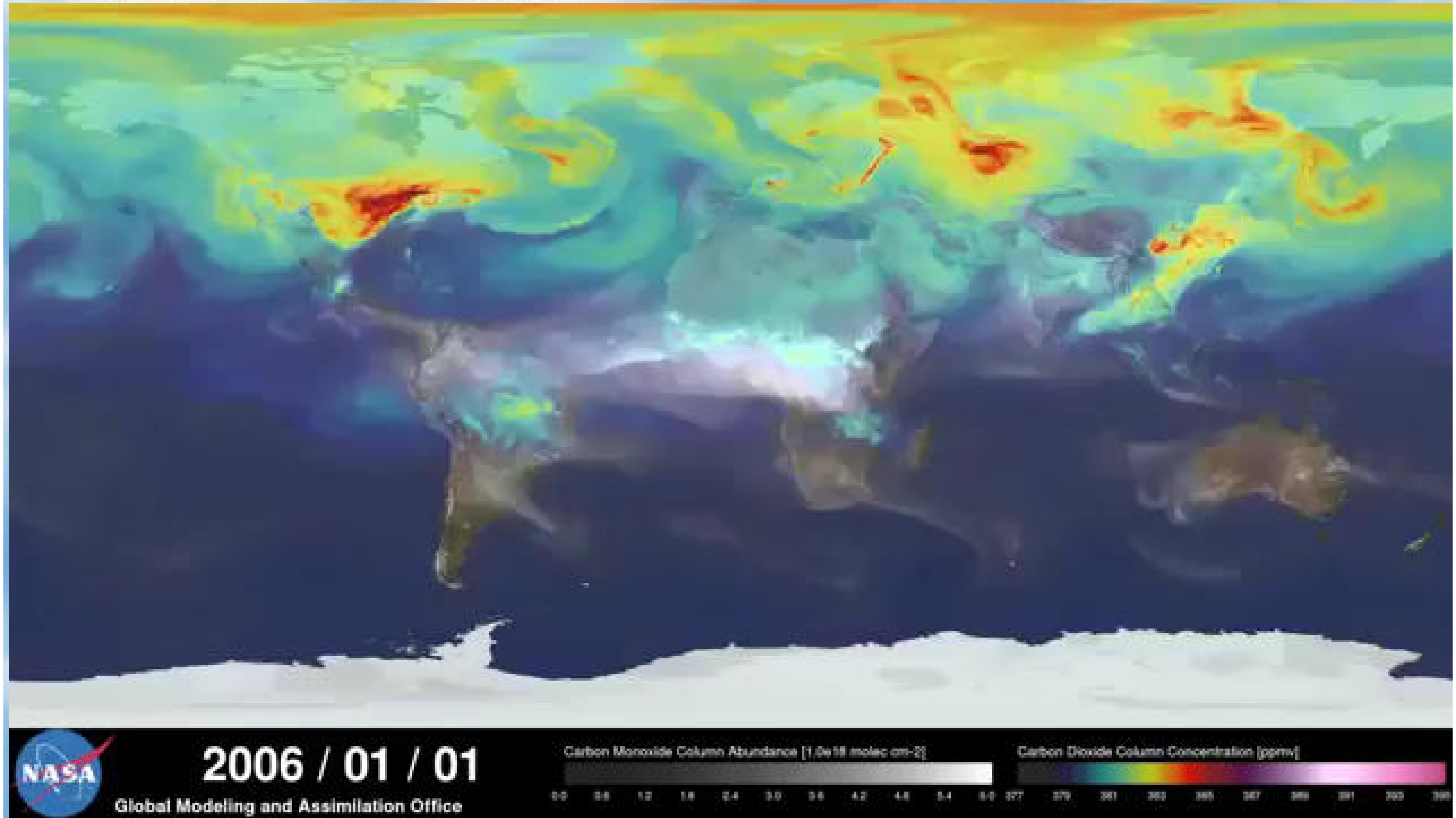
Ometto et al., 2022

Fluxos de energia em nosso planeta



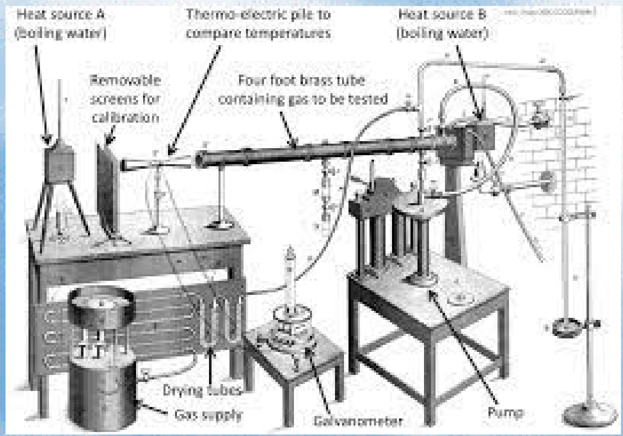
Around the World with Energy
Surface temperature (colors 270-310 Kelvin) and outgoing longwave radiation at the top of the atmosphere (white) representative of clouds in the model.
GEOS-5 simulation of surface temperatures between May 2005 and May 2007. Colors show surface temperatures ranging from 270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

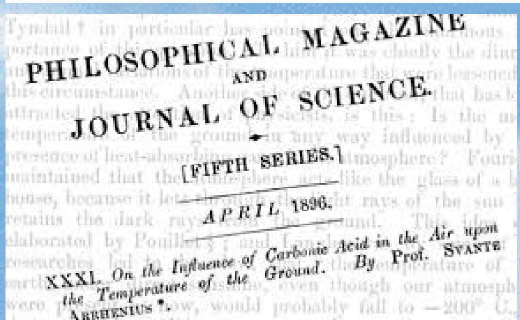
Distribuição global de CO_2



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

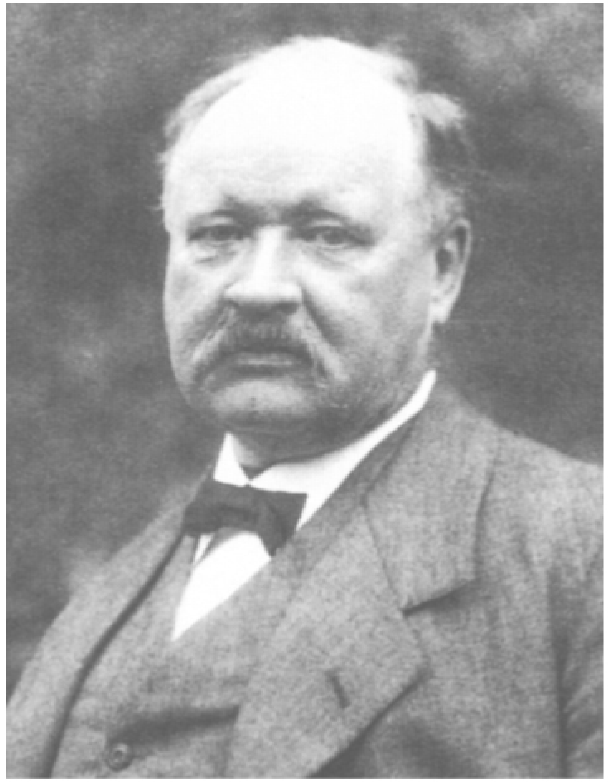
Em 1896, a primeira previsão climática: Svante Arrhenius




PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.
[FIFTH SERIES.]
APRIL 1896.
XXXI. On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground. By Prof. SVANTE ARRHENIUS *.

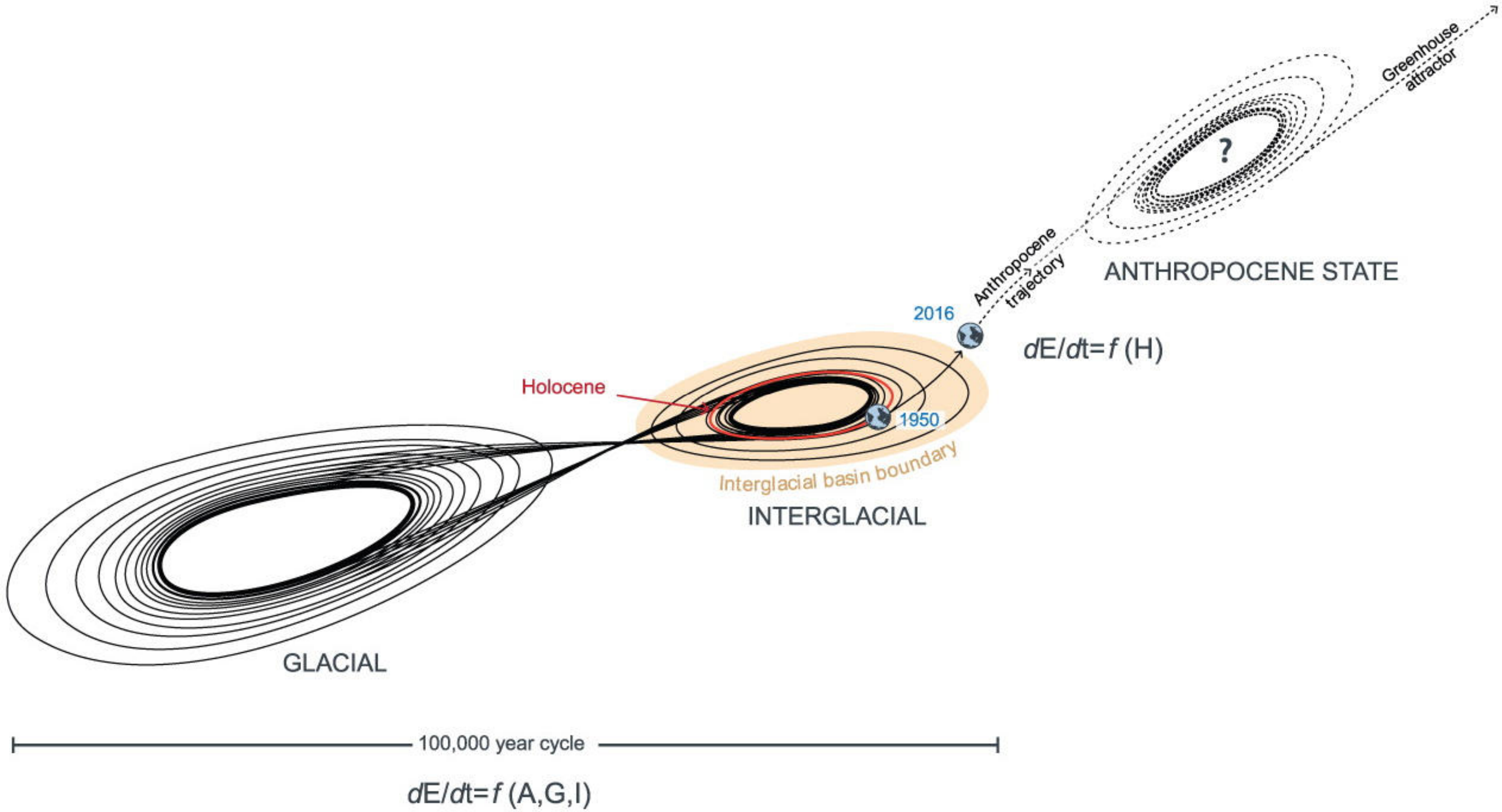
Arrhenius quantificou em 1896 as mudanças na temperatura da superfície (aprox. 5 C) que deveriam ocorrer se dobrássemos a concentração de CO_2, baseado nos conceitos introduzidos em 1824 por Joseph Fourier


THE
LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.
[FIFTH SERIES.]
APRIL 1896.


Arrhenius

Um sistema dinâmico complexo

Os atratores de nosso novo clima e o futuro do antropoceno



The trajectory beyond 2016 indicates a significant departure from the glacial–interglacial limit cycle of the late Quaternary, and a unique event in Earth's history. Beyond it lies a greenhouse attractor.

Owen Gaffney; Will Steffen; The Anthropocene Review, 2017

Das emissões de gases de efeito estufa aos impactos

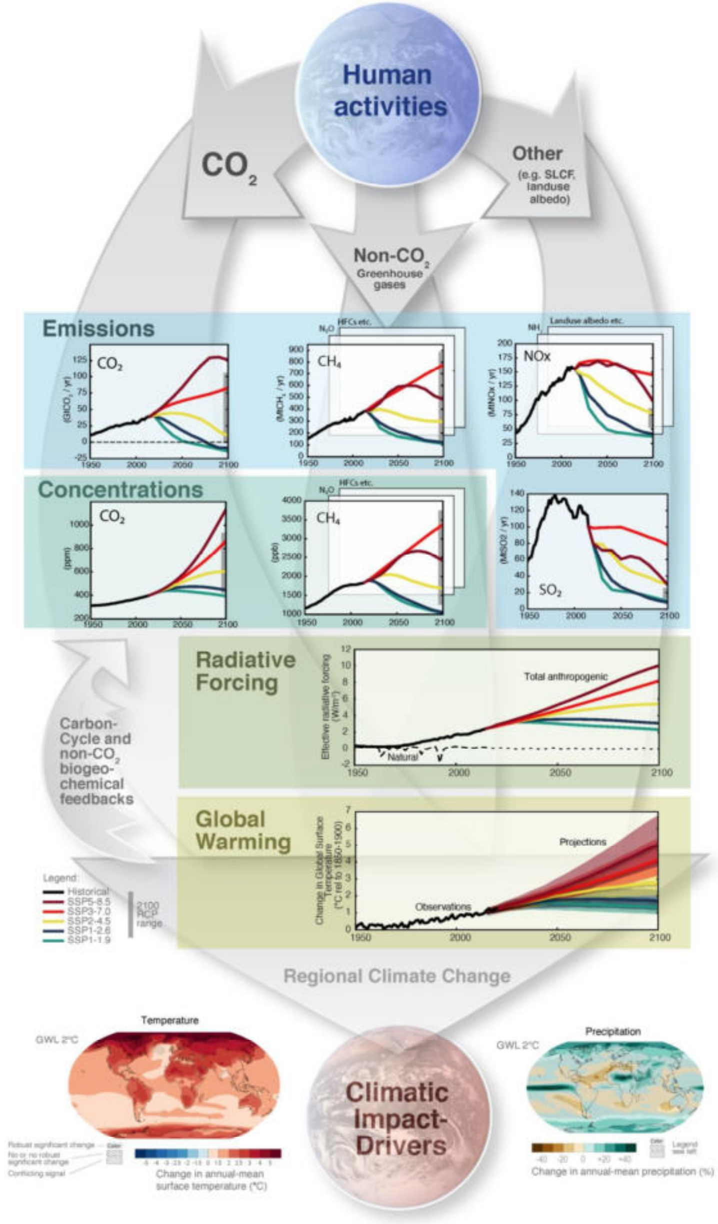
Emissões

Concentrações

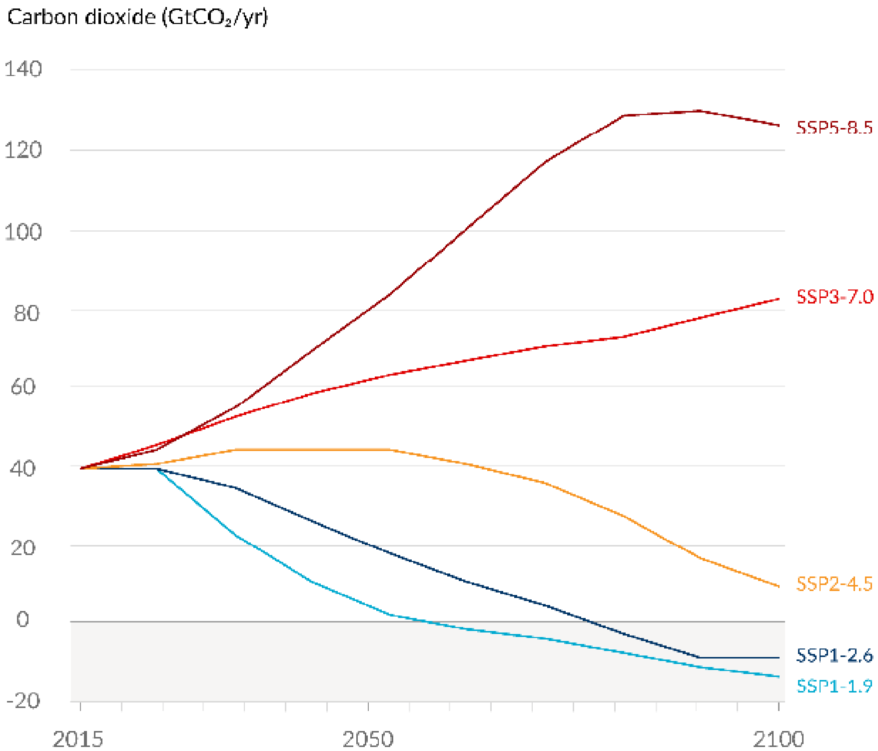
Forçantes Radiativas

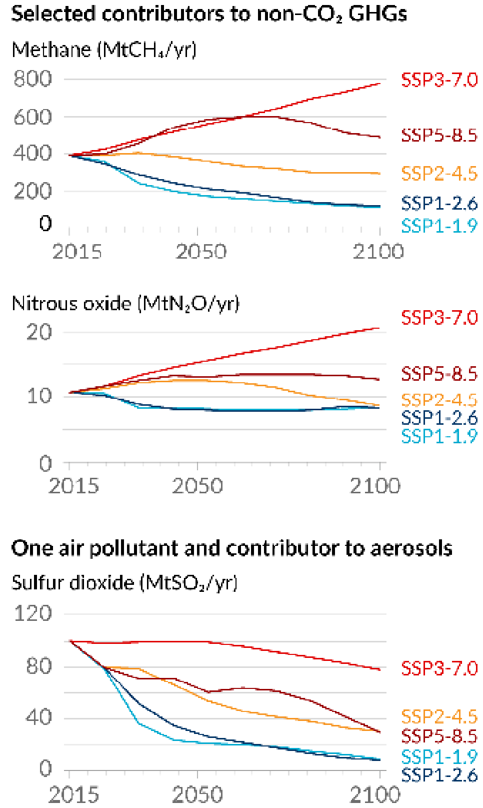
Aquecimento

Impactos



Cinco cenários de emissões futuras associados a estratégias socioeconômicas

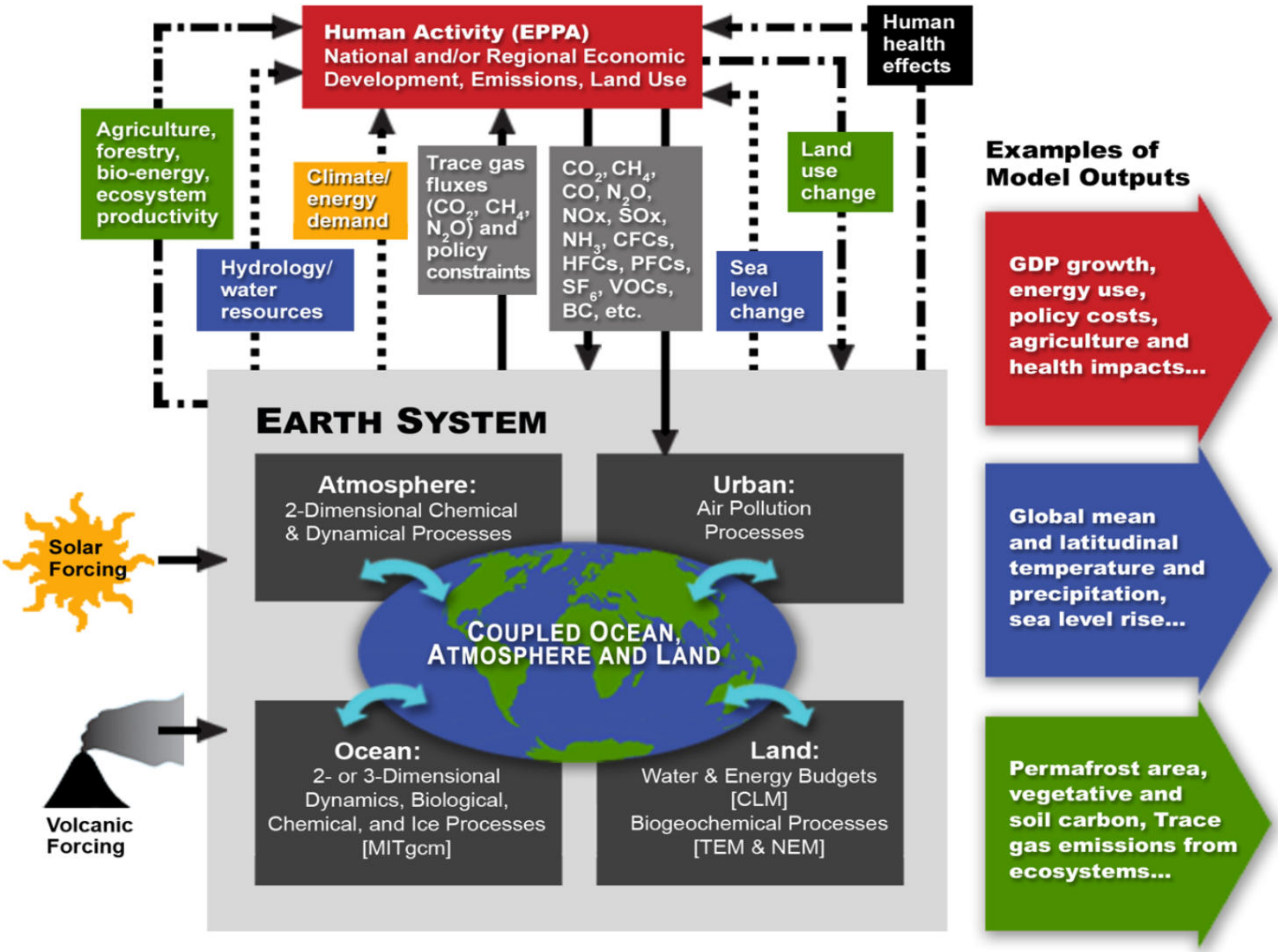




Metano: GWP de 50

Óxido nitroso

Aerossóis



Human Activity (EPPA)
National and/or Regional Economic Development, Emissions, Land Use
Human health effects
Agriculture, forestry, bio-energy, ecosystem productivity
Climate/ energy demand
Trace gas fluxes (CO_2, CH_4, N_2O) and policy constraints
CO_2, CH_4, CO, N_2O, NOx, SOx, NH_3, CFCs, HFCs, PFCs, SF_6, VOCs, BC, etc.
Land use change
Hydrology/ water resources
Sea level change
Examples of Model Outputs
GDP growth, energy use, policy costs, agriculture and health impacts...
Global mean and latitudinal temperature and precipitation, sea level rise...
Permafrost area, vegetative and soil carbon, Trace gas emissions from ecosystems...
EARTH SYSTEM
Atmosphere:
2-Dimensional Chemical & Dynamical Processes
Urban:
Air Pollution Processes
COUPLED OCEAN, ATMOSPHERE AND LAND
Ocean:
2- or 3-Dimensional Dynamics, Biological, Chemical, and Ice Processes [MITgcm]
Land:
Water & Energy Budgets [CLM] Biogeochemical Processes [TEM & NEM]
Solar Forcing
Volcanic Forcing

A forçante radiativa do sistema climático terrestre

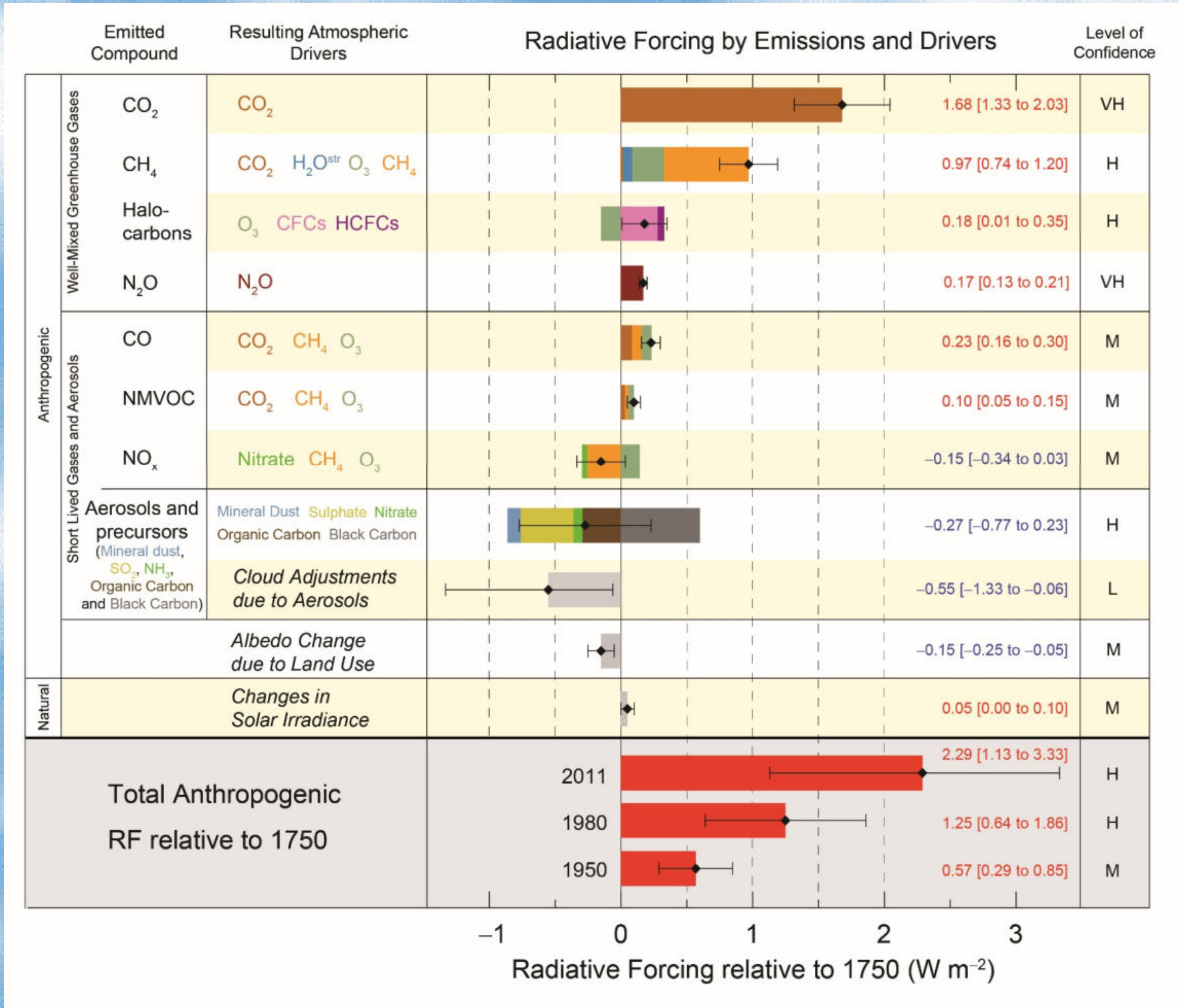


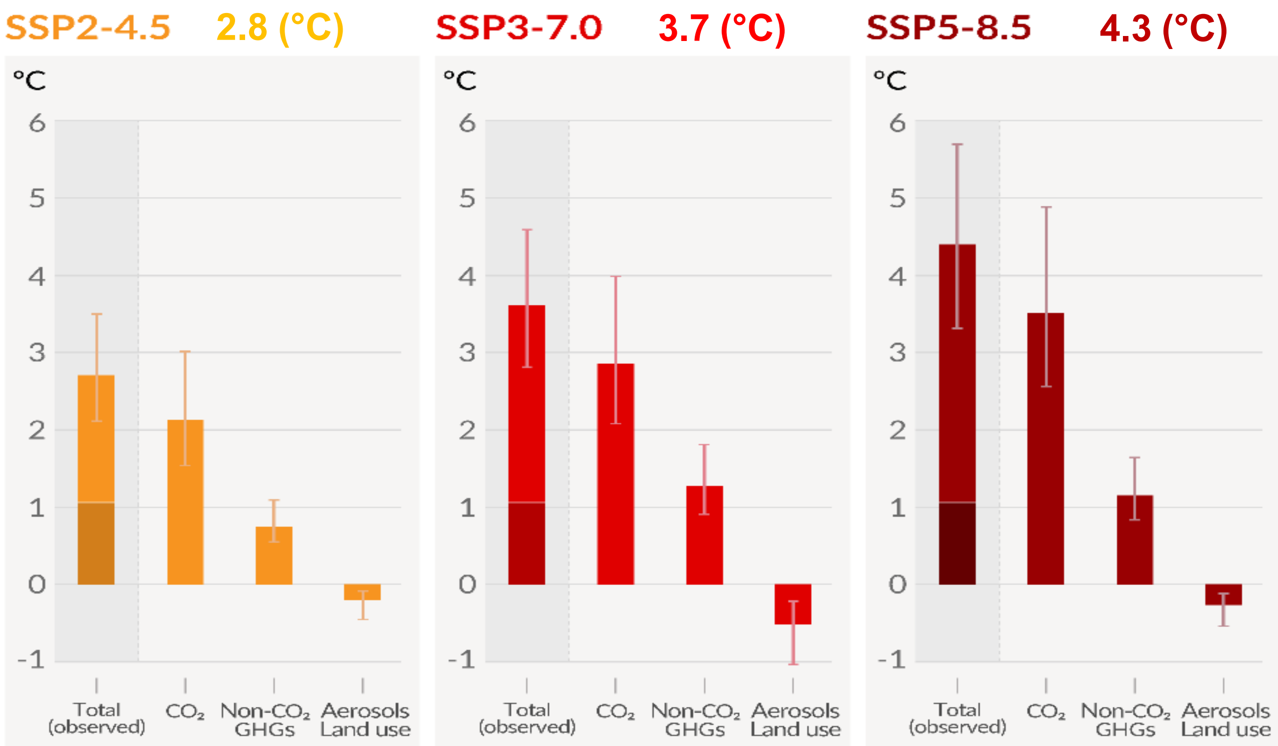
Figure SPM.4

Aquecimento global em 2081-2100 relativo a 1850-1900 (°C)

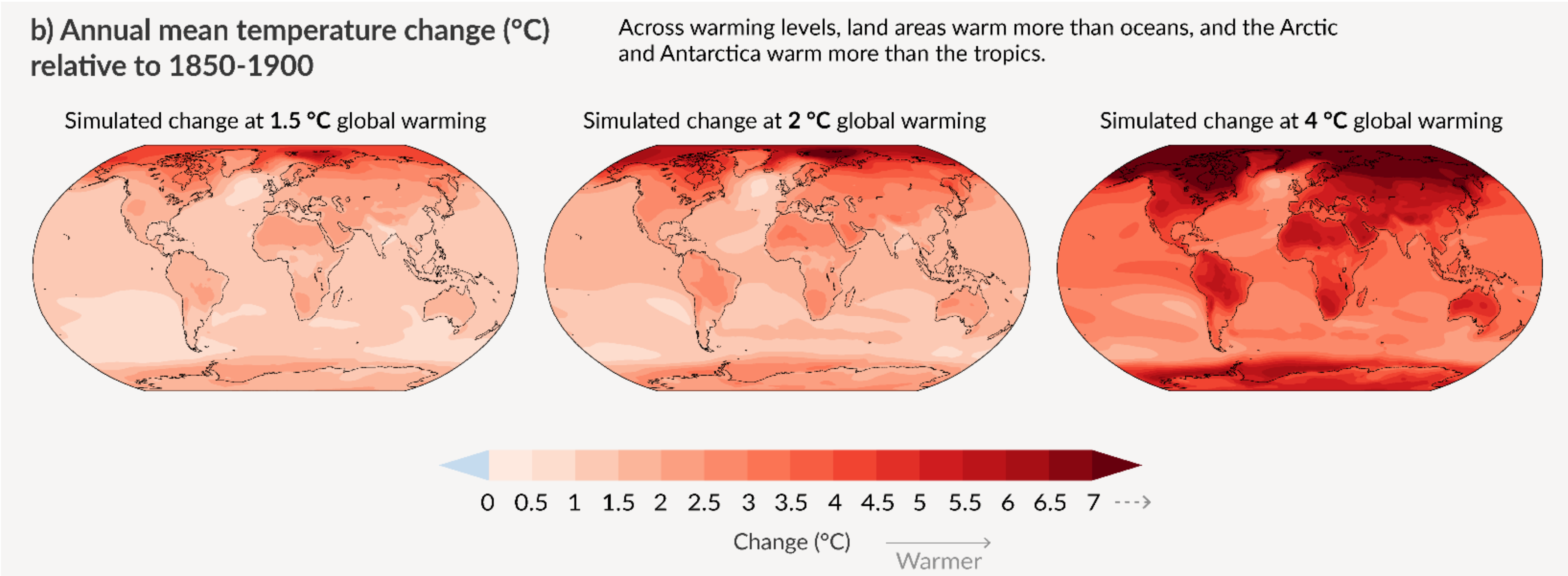
Estamos caminhando para um aumento médio de temperatura de 3.7 a 4.3 Celsius

Com fortes ações previstas na COP26, 2.8 °C

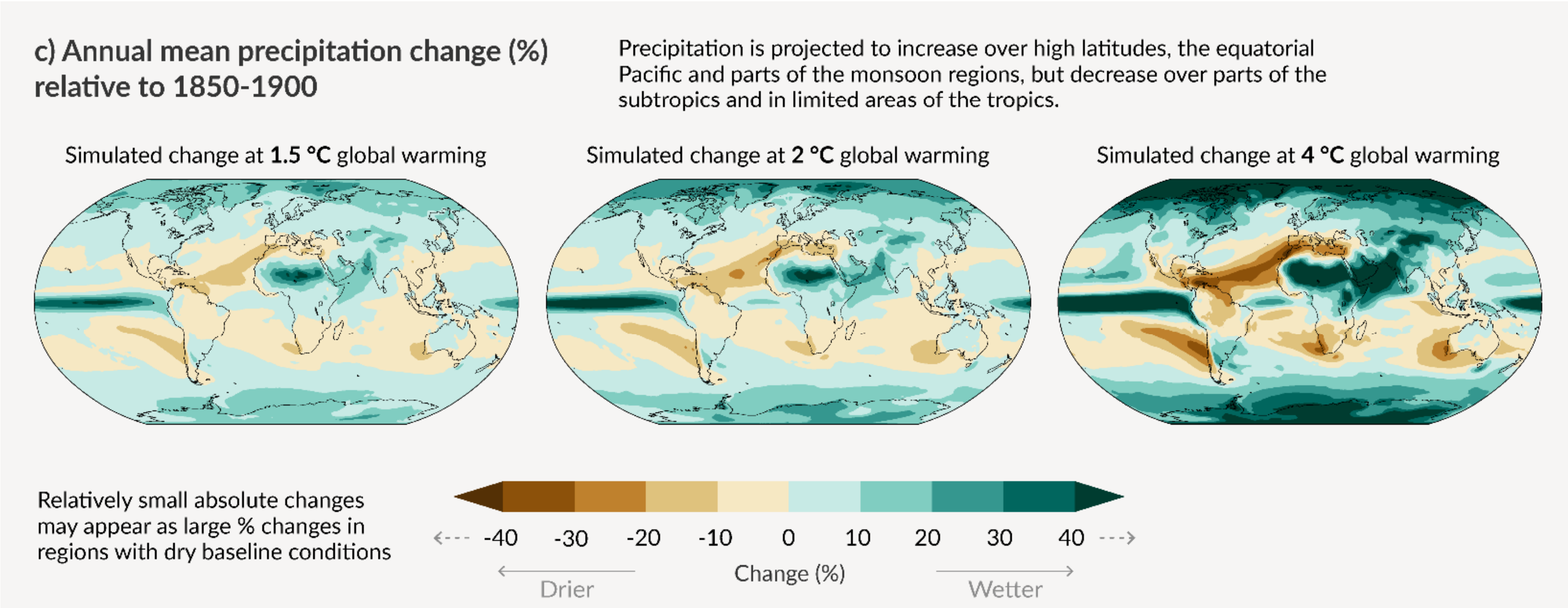
Missão impossível: limitar a 1.5 °C, ou 2 °C



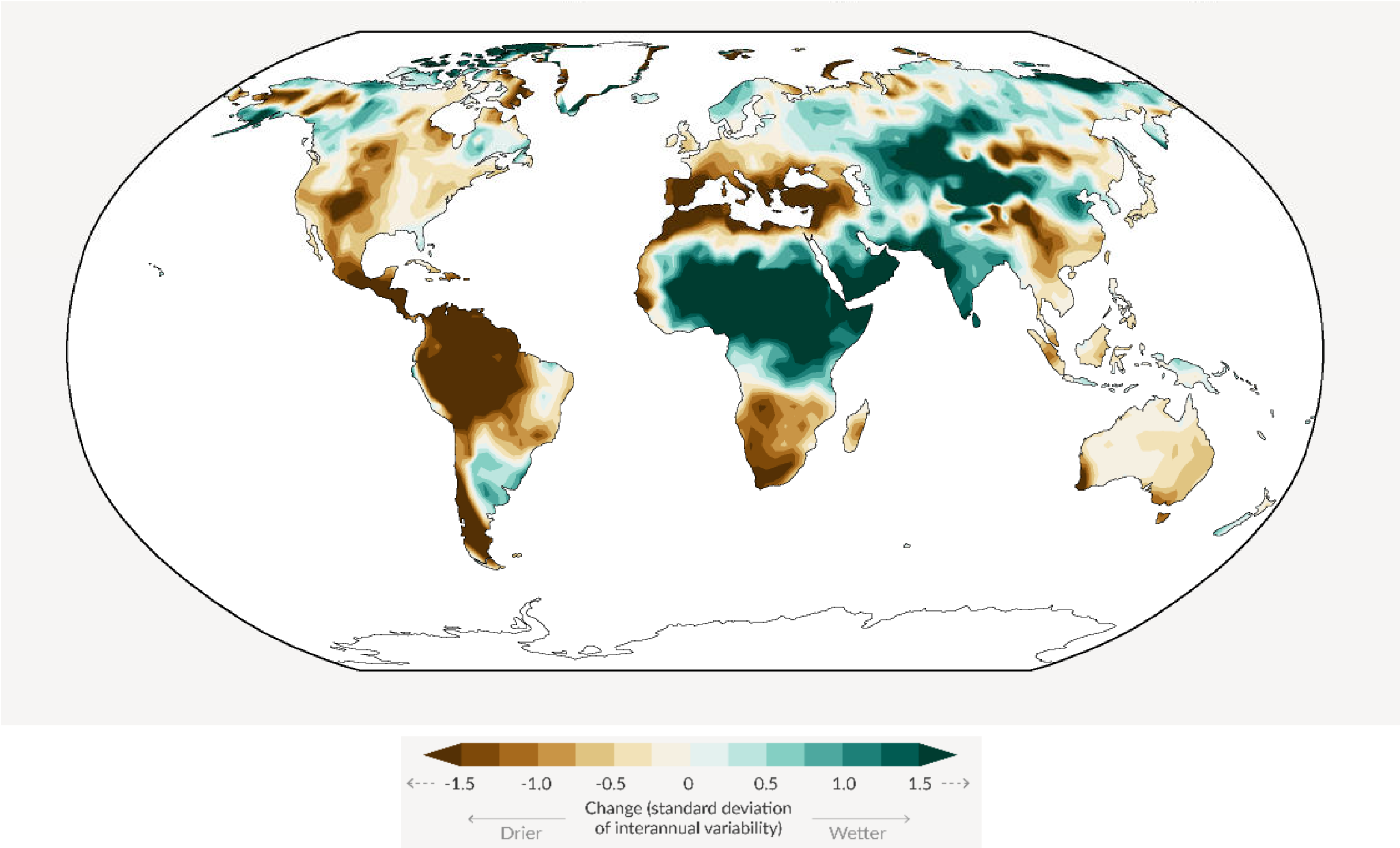
Com cada aumento no aquecimento, mudanças ficam maiores na temperatura



Com cada aumento no aquecimento, mudanças ficam maiores na precipitação



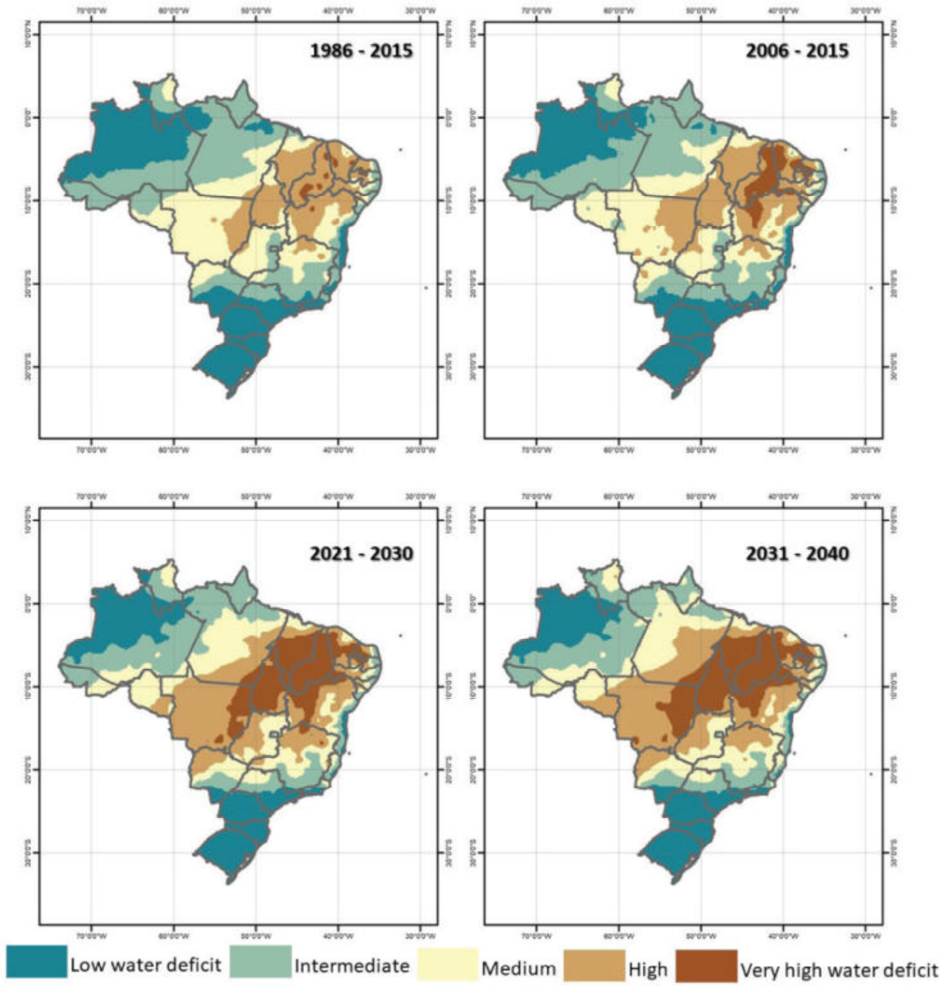
Mudança na umidade do solo com 4 graus de aquecimento



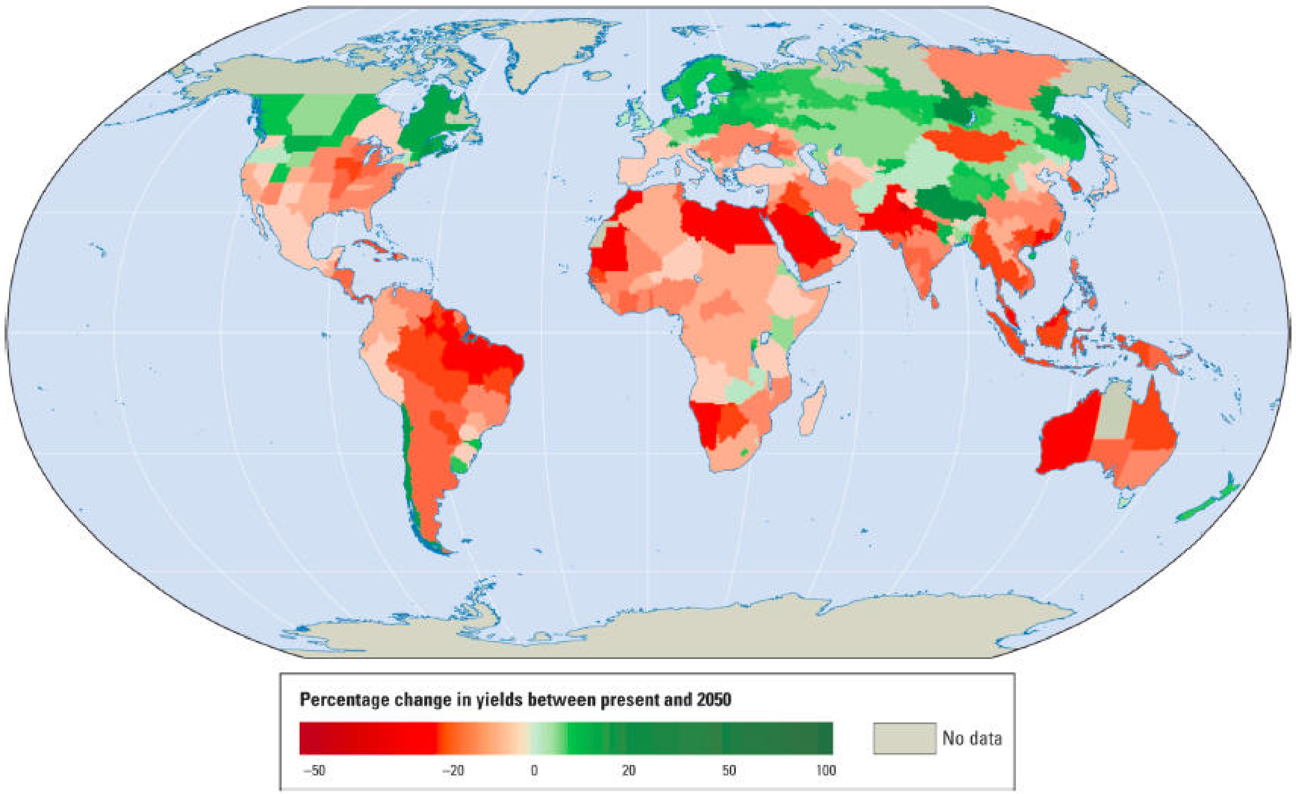
Déficit de água no Brasil 1986-2040

Brasil já está se tornando uma área mais seca

Embrapa Informática Agropecuária, 2019



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



World Economic Forum: Global Risks 2016

Aumento dos eventos climáticos extremos em todo o Planeta

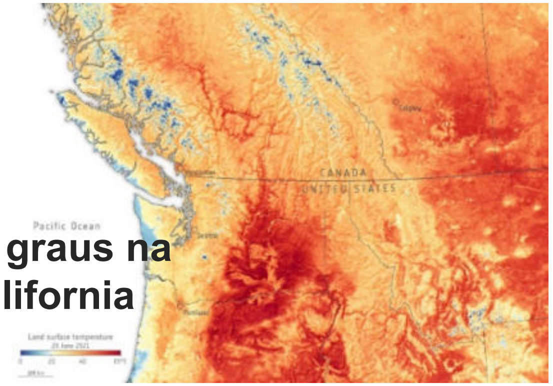
Cientistas associam fortes chuvas na Europa às mudanças climáticas

Chuvas sem precedentes deixam 126 mortos na Europa e disparam alerta contra mudanças climáticas

Precipitação bate recordes na Alemanha e, com mais de 1.300 desaparecidos, número de vítimas deve aumentar

MAIOR CHUVA EM UM SÉCULO NA ALEMANHA

O desastre da chuva na Alemanha e Bélgica fez com que diversos cientistas estudiosos das mudanças climáticas alertasse que estes eventos extremos de precipitação tendem a se tornar cada vez mais comuns.



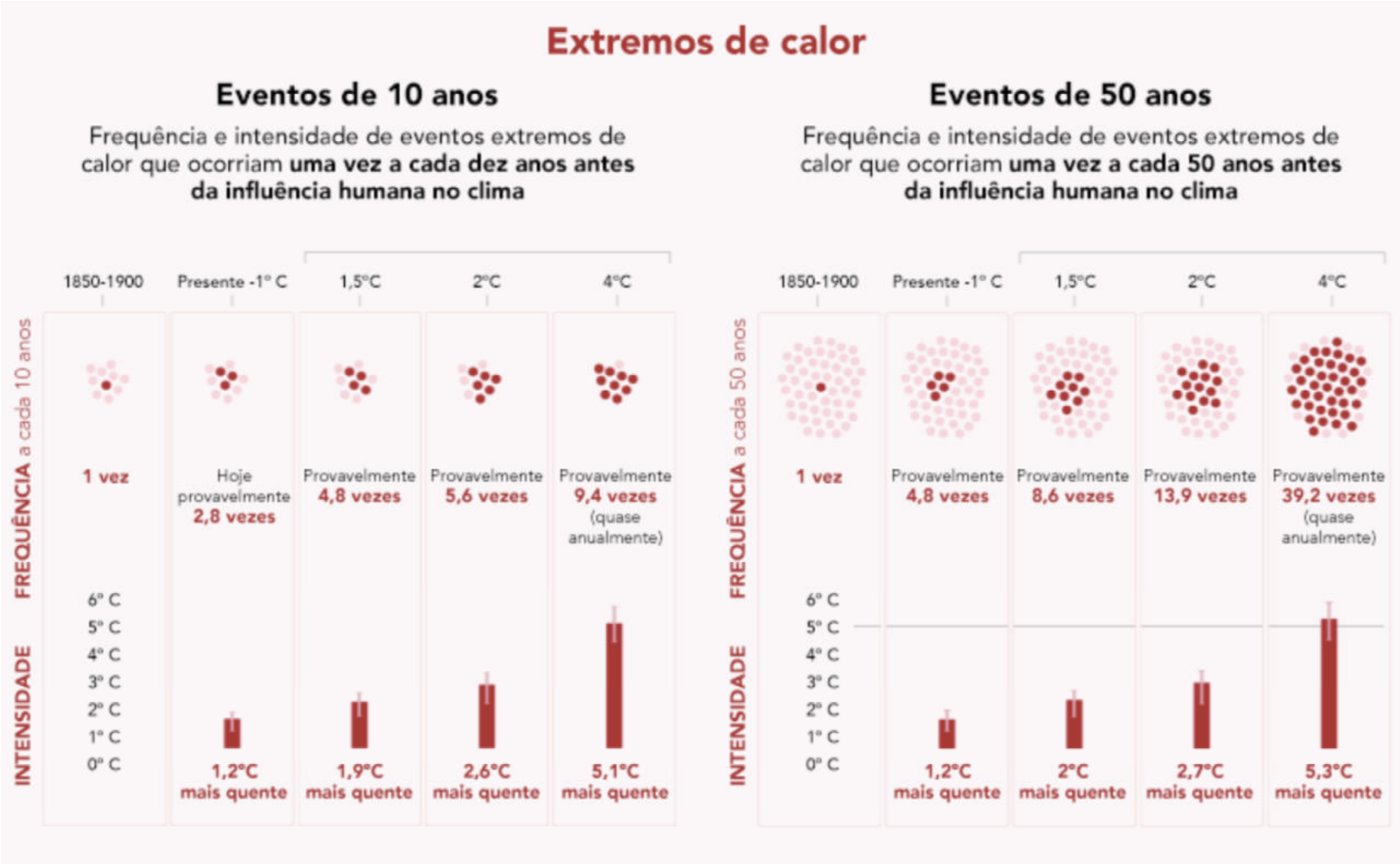
52 graus na California

A crise hídrica chega ao Planalto Central

2021: Rio Negro registra a maior cheia em 119 anos em Manaus

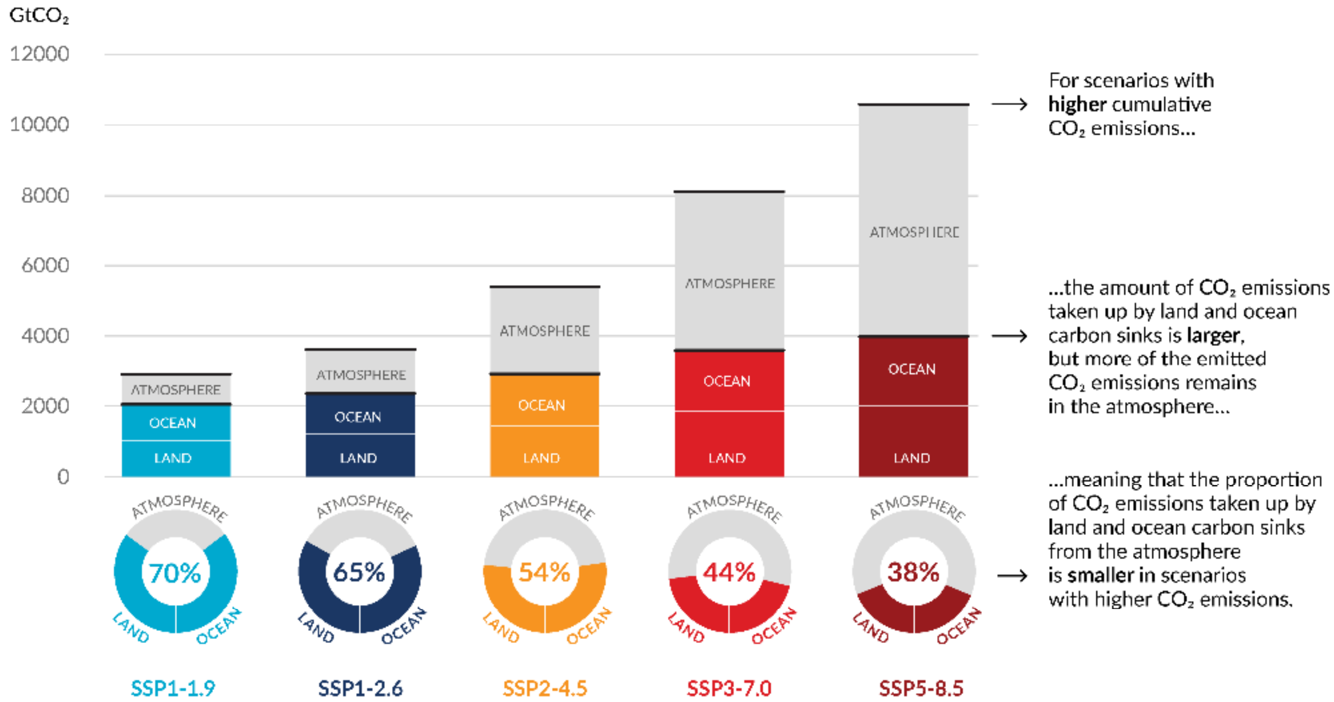
Figure SPM.6

A frequência projetada de extremos e sua intensidade aumentam com cada grau de aquecimento adicional



A proporção de emissões de CO_2 que está sendo absorvida pelos oceanos e ecossistemas terrestres estão diminuindo com o aumento de emissões

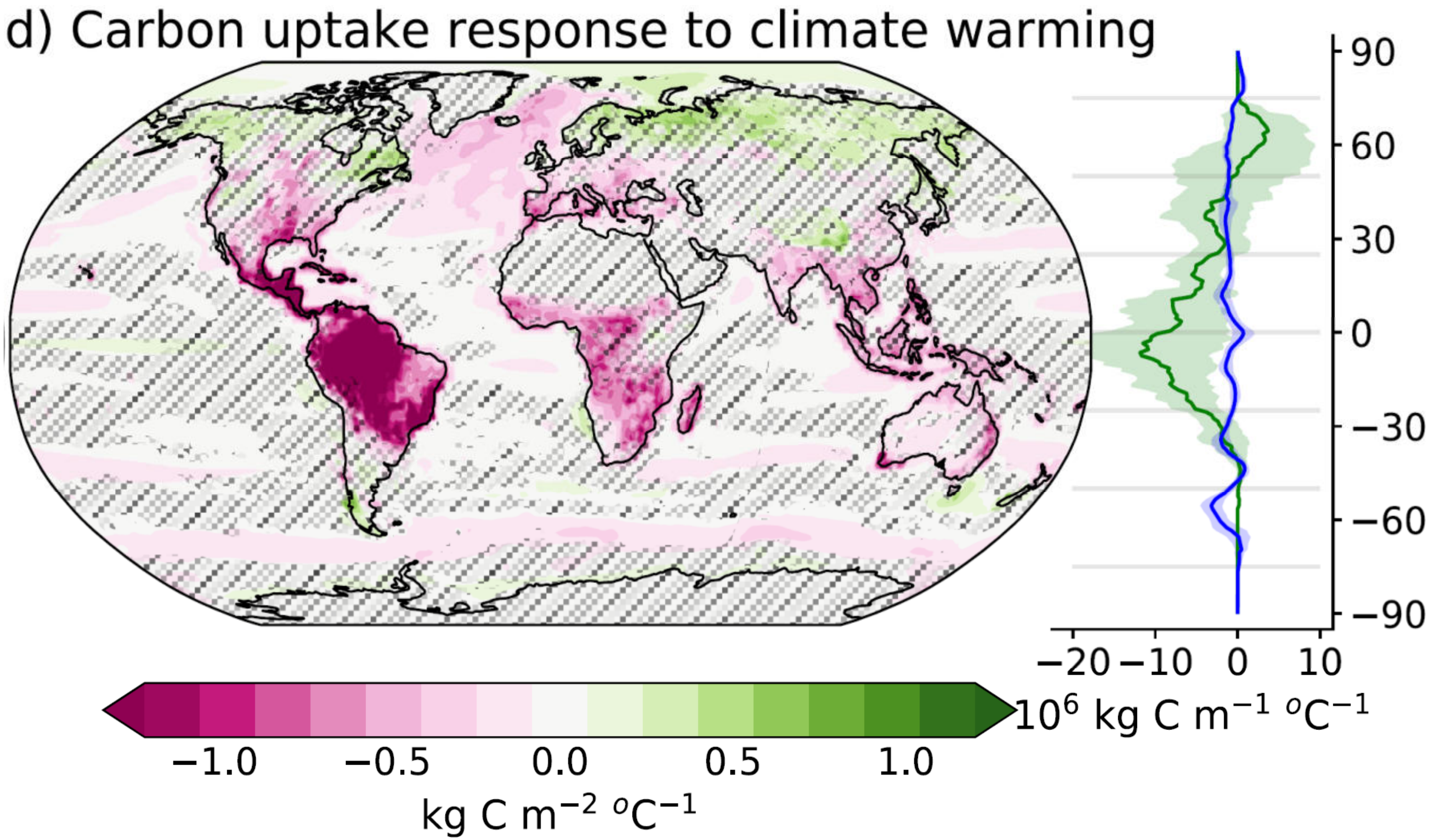
Total cumulative CO_2 emissions **taken up by land and oceans** (colours) and remaining in the atmosphere (grey) under the five illustrative scenarios from 1850 to 2100



Hoje, oceanos e ecossistemas terrestres absorvem 70% das emissões. No futuro podem absorver somente 38%. Isso acelera o aquecimento

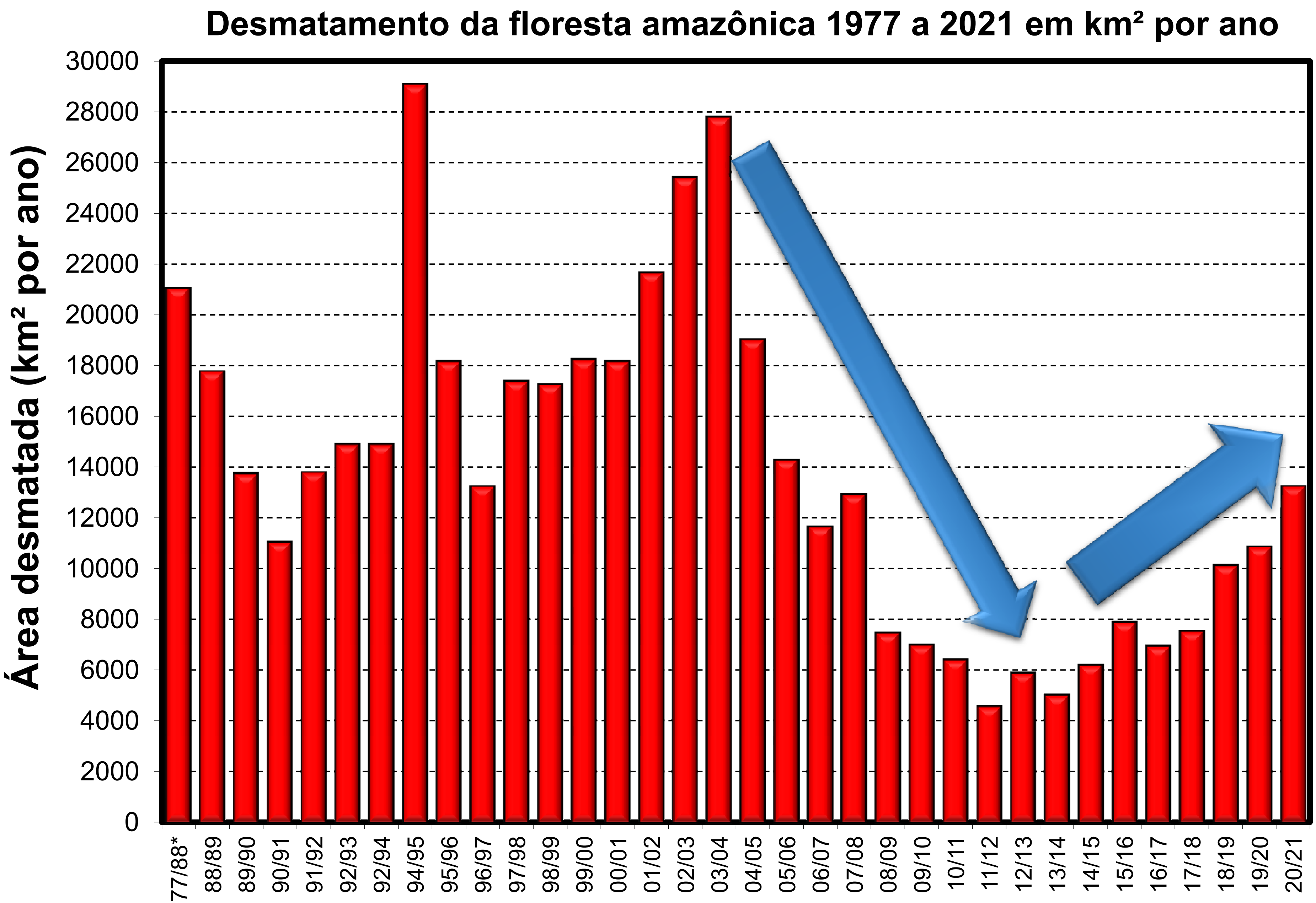
Figure SPM.7

E a Amazônia? Fonte ou emissora de carbono?



IPCC AR6 TS pg. 122


Amazônia e Mudanças Climáticas Globais:
Processo de duas vias
Desmatamento e mudanças climáticas



Desmatamento da floresta amazônica 1977 a 2021 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
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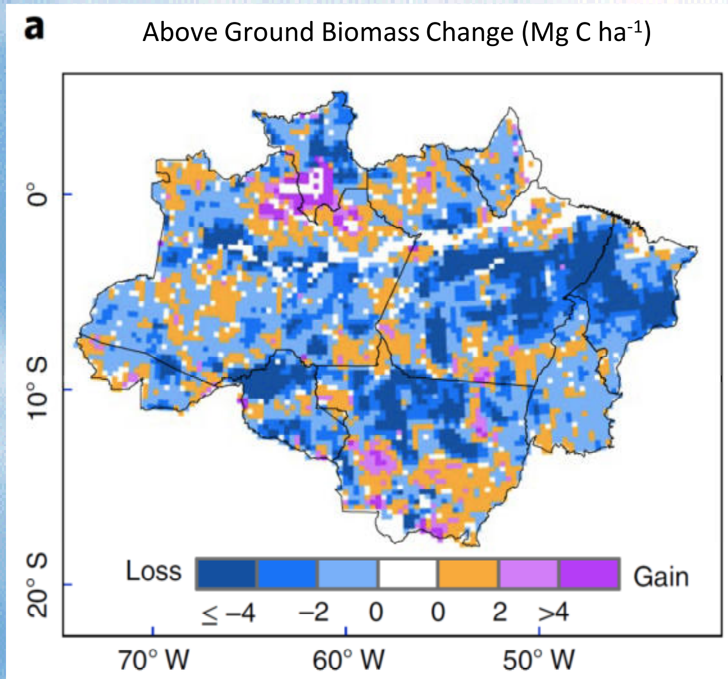
19/20
20/21

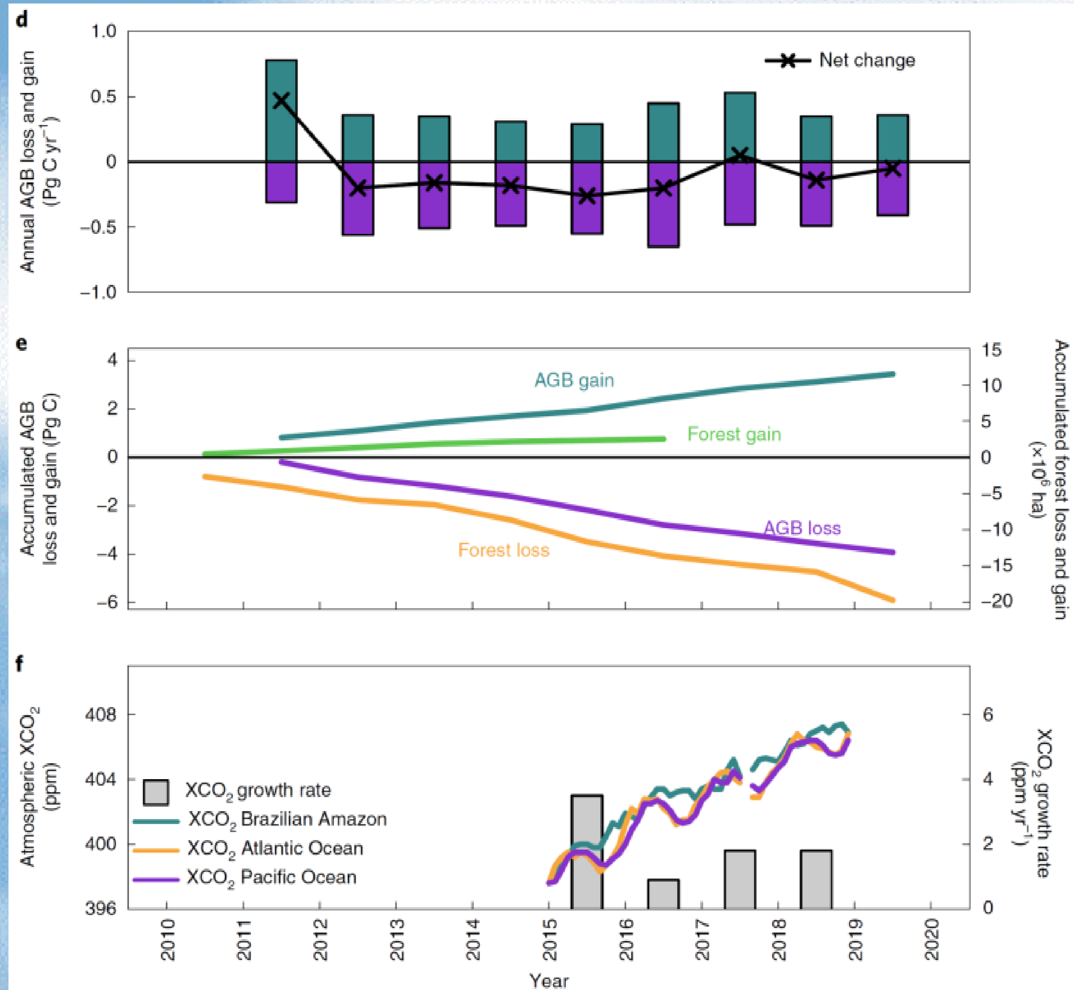
ARTICLES | FOCUS
https://doi.org/10.1038/s41558-021-01026-5
nature climate change

Check for updates

Carbon loss from forest degradation exceeds that from deforestation in the Brazilian Amazon

Yuanwei Qin[1], Xiangming Xiao[1✉], Jean-Pierre Wigneron[2✉], Philippe Ciais[3], Martin Brandt[4], Lei Fan[5], Xiaojun Li[2], Sean Crowell[6], Xiaocui Wu[1], Russell Doughty[1,7], Yao Zhang[8], Fang Liu[9], Stephen Sitch[10] and Berrien Moore III[6]

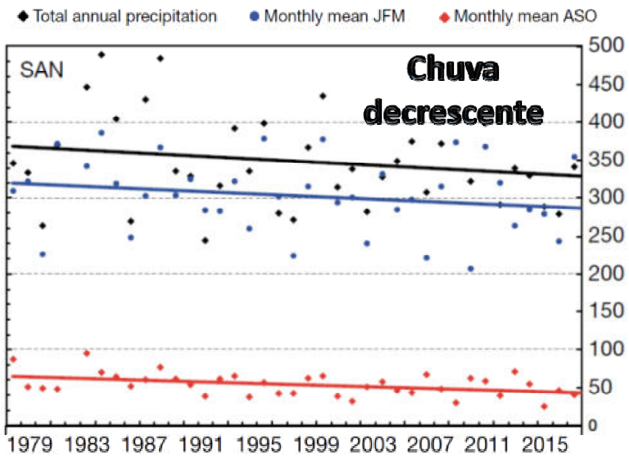


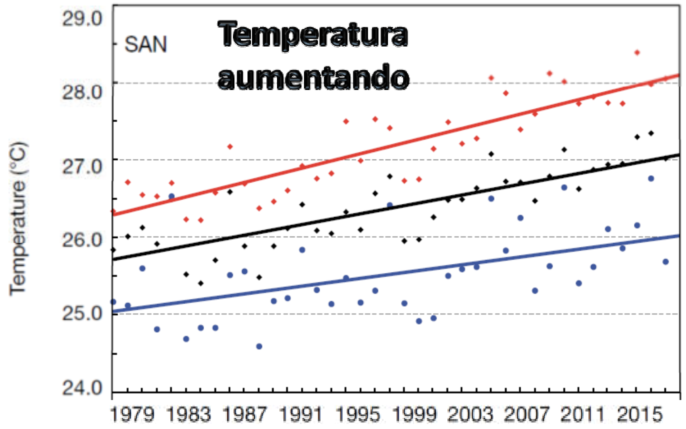


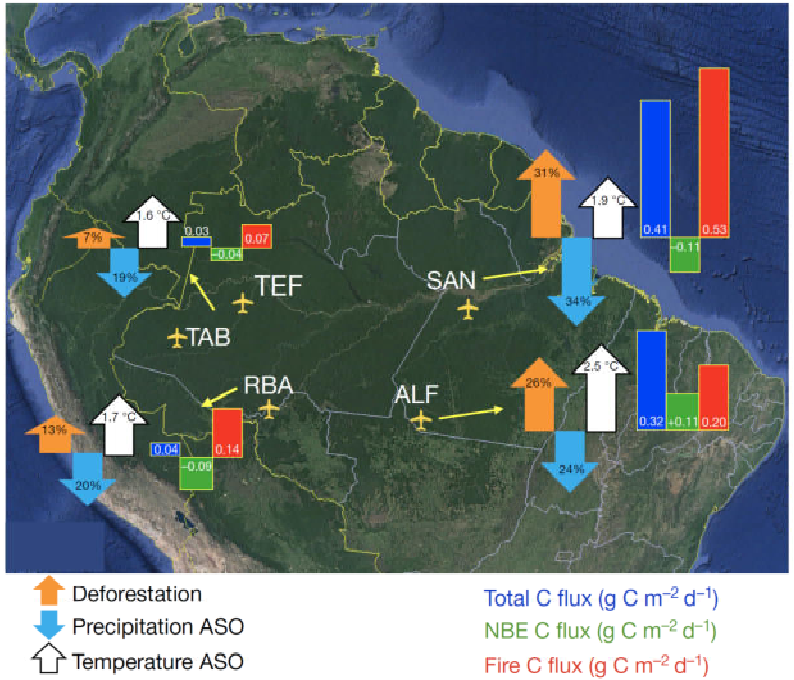
Durante 2010–2019,a Amazônia brasileira teve uma perda bruta cumulativa de 4,45 Pg C contra um ganho bruto de 3,78 Pg C, resultando em uma perda líquida de biomassa de 0,67 Pg C. A degradação florestal (73%) contribuiu três vezes mais para a perda bruta de biomassa do que o desmatamento (27%), Isso indica que a degradação florestal se tornou a maior processo que leva à perda de carbono.

Yuanwei Qin et al., Nature Climate Change, Maio de 2021

Balanço de carbono na Amazônia: desmatamento e mudança climática







Amazonia pode já estar se tornando uma fonte importante de carbono

Balanço de carbono para a região de Alta Floresta de 2010 a 2018

Total Carbon Balance: +0.32 PgC y^{-1}

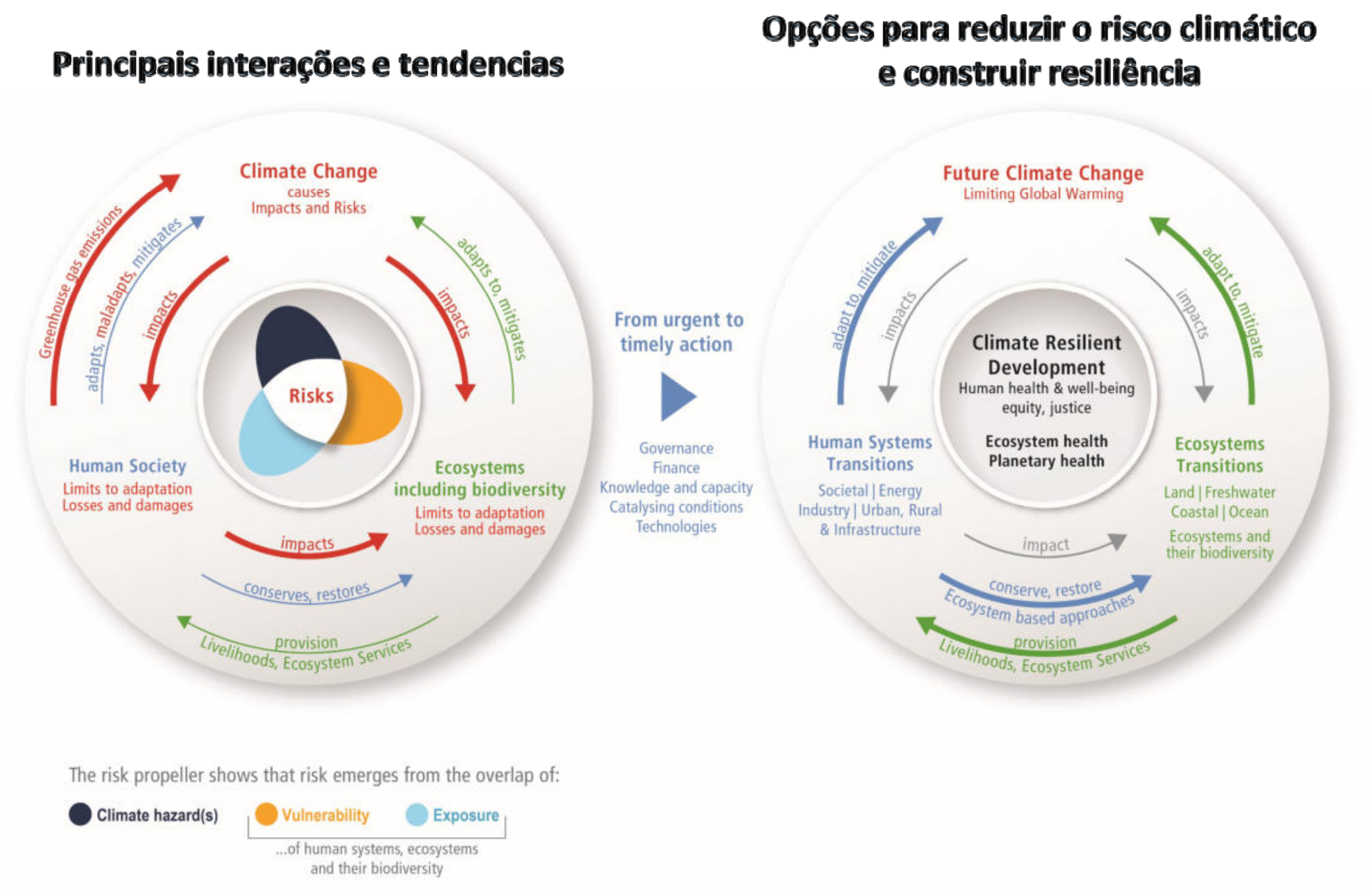
Fire Carbon Balance: +0.20 PgC y^{-1}

NBE (Net Biome Exchange) C Balance: +0.11 PgC y^{-1}

Gatti et al., Nature, 2021


A Amazônia é critica
para o transporte de
vapor de água para
o Brasil central e sul
1610 km
Image NASA
Google

Dos riscos climáticos ao desenvolvimento resiliente ao clima



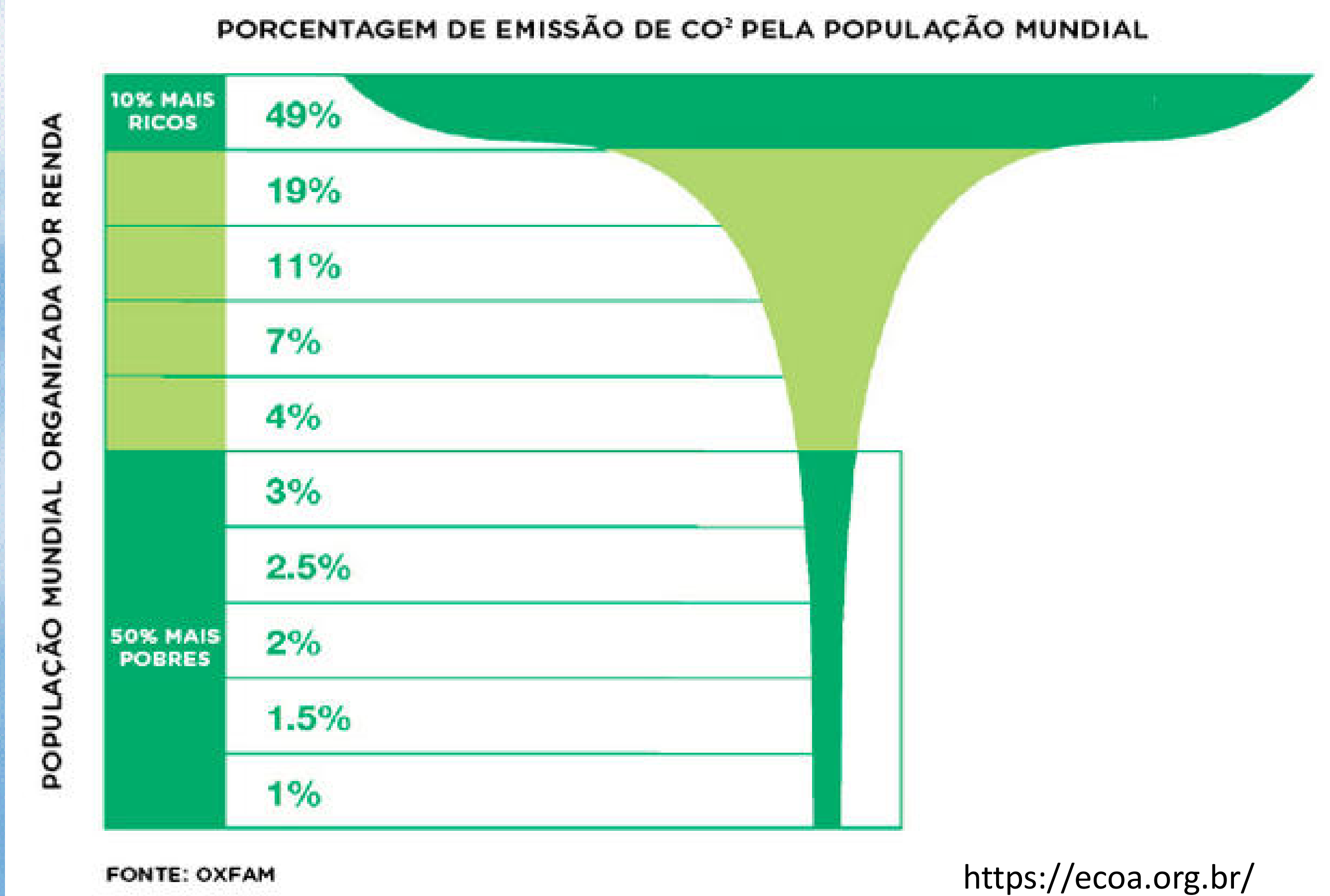
Evidências Impactos, Vulnerabilidades e Adaptação

- Justiça Climática
- Limites de Adaptação (suaves e duros)
- Perdas e Danos (econômicos & não-econômicos NELD)
- Pontos de Inflexões Sociais (Social tipping Point)
- Riscos Residuais (Perdas e Danos)

Porcentagem de emissão de CO_2 pela população mundial

Os 10% mais ricos emitem 49% dos gases

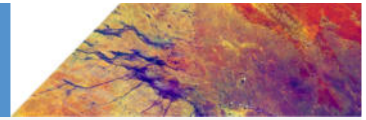
Os 50% mais pobres emitem 10% dos gases



https://ecoa.org.br/

Para onde estamos caminhando?

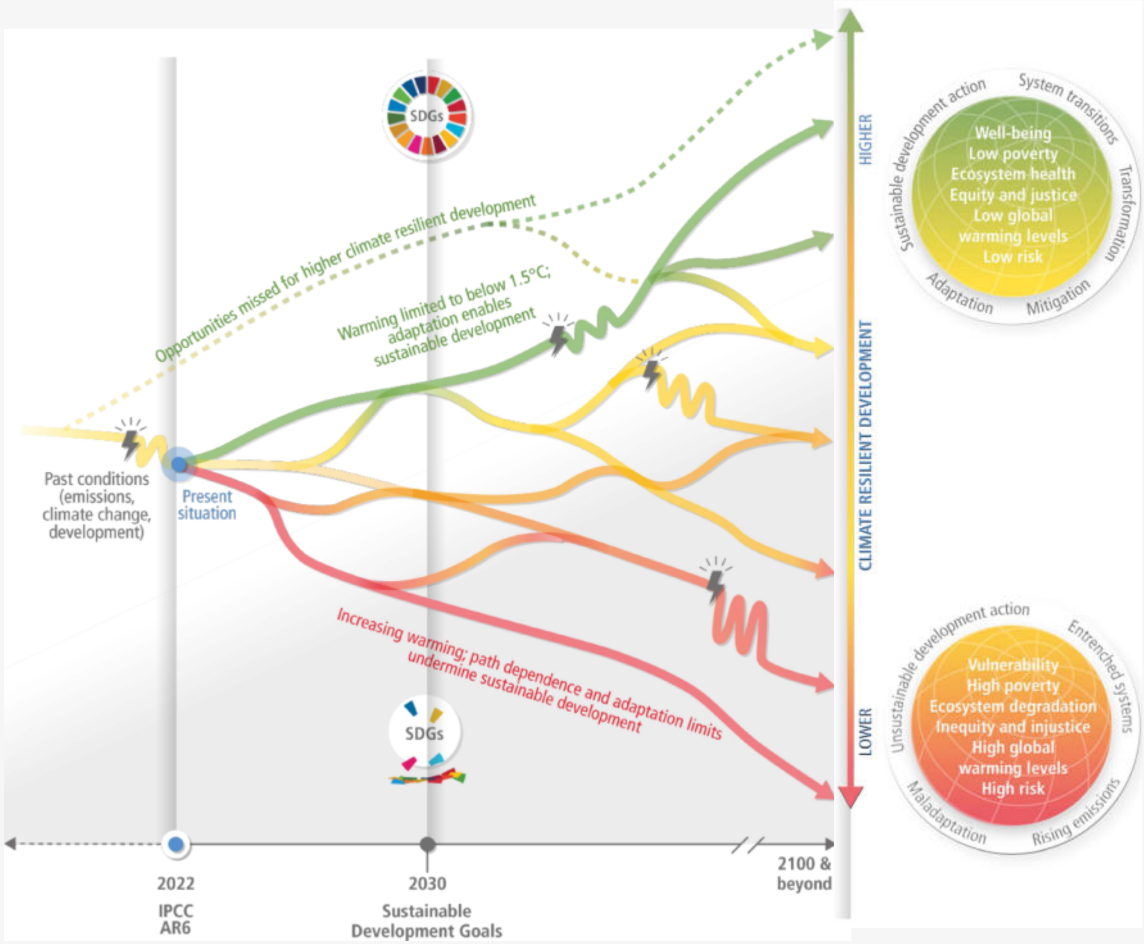
- Cálculo simples e realista levando em conta o cumprimento do Acordo de Paris: **3.2** graus de aquecimento médio
- Em áreas continentais (+1C): **4.2** C
- Remoção de aerossóis, pela redução da poluição do ar: + 0.7 C, chegando a **4.9** C
- 80% da população viverá em áreas urbanas: intensificação da ilha de calor urbana: Mais 0.7 C, totalizando **5.6** C
- Estamos indo na trajetória de aquecimento de **5.6** C aonde vive a população (em cidades)

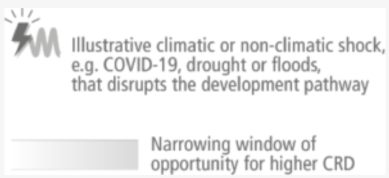


Increasing urgency

Starting today, every action, every decision matters.

Worldwide action is more urgent than previously assessed.

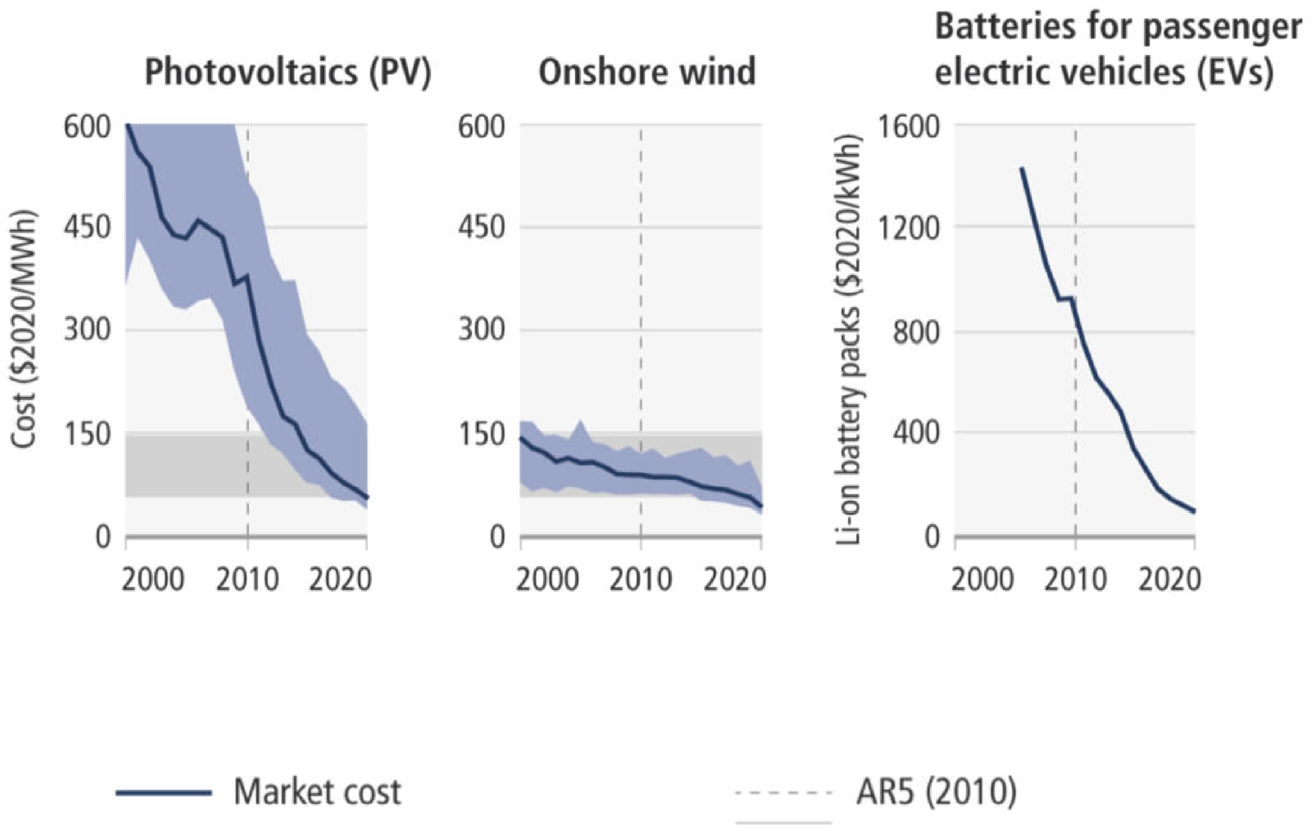




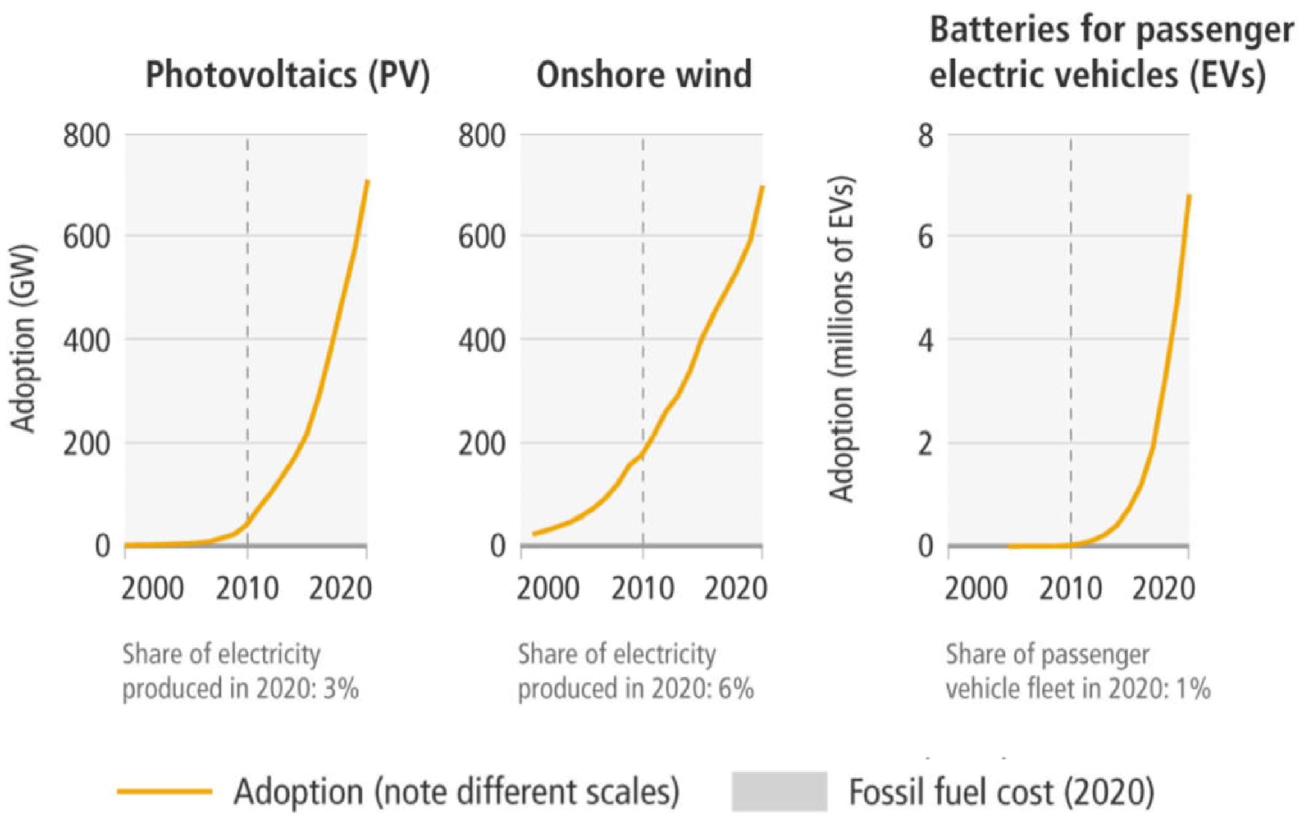
ipcc
INTERGOVERNMENTAL PANEL ON climate change

There are options available **now** in every sector that can at least **halve** emissions by 2030

Sixth Assessment Report
WORKING GROUP III – MITIGATION OF CLIMATE CHANGE



In some cases, costs for renewables have fallen below those of fossil fuels.



Electricity systems in some countries and regions are already predominantly powered by renewables.

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

Olhem para o futuro

As seis grandes transformações necessárias para o mundo em 2050

Energia

Decarbonização, eficiência,
acesso à energia

Consumo e Produção Sustentáveis

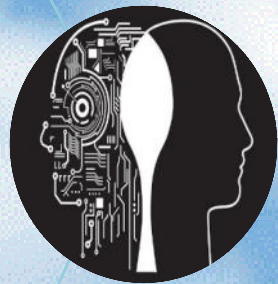
Uso de recursos, economia circular,
suficiência, poluição

Alimentos, Usos da Terra & Biosfera

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

Objetivos de Desenvolvimento Sustentáveis:

- Prosperidade
- Inclusão social
- Sustentabilidade
- Paz social



Revolução Digital

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

Cidades

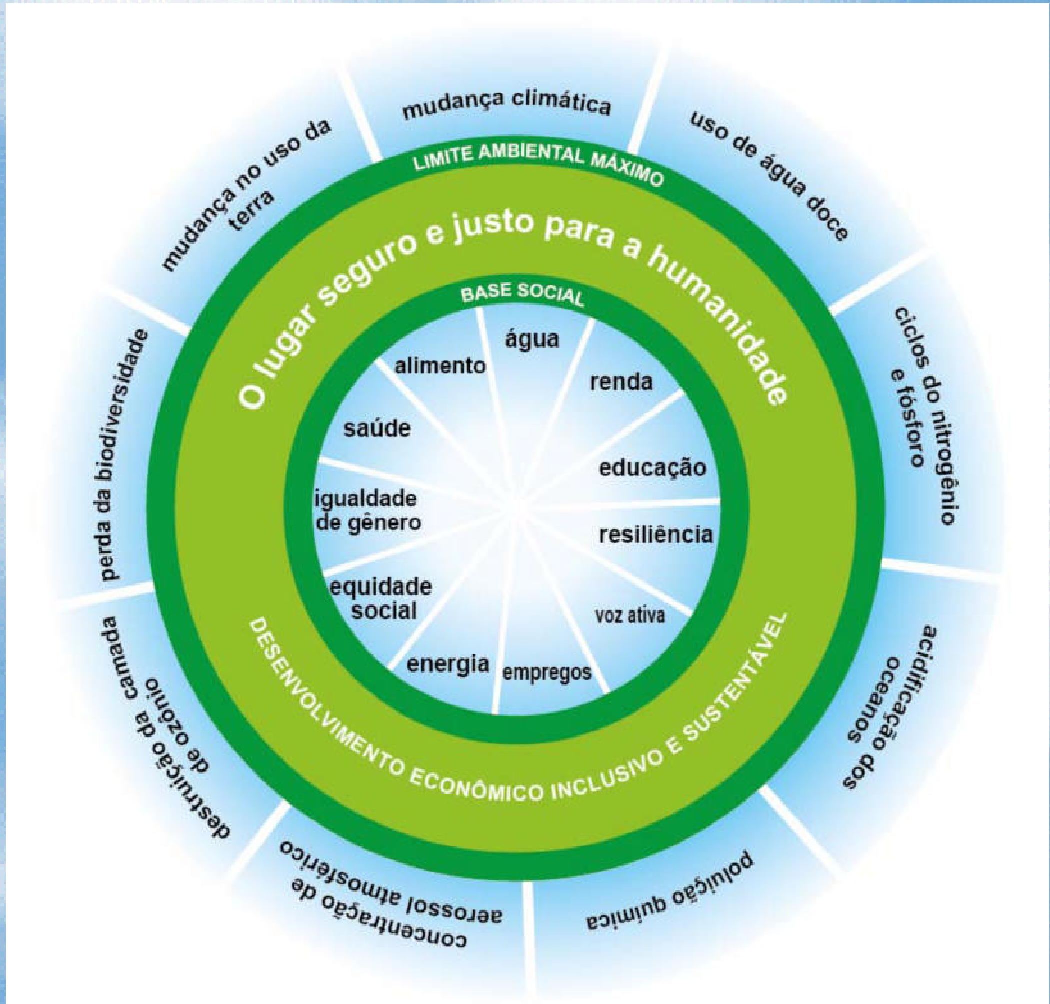
Moradia, mobilidade,
Infraestrutura sustentável,
água, poluição

Capacitação Humana & Demografia

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

Como construir um espaço seguro e justo para nossa humanidade?

Combinando o Sistema Terrestre com aspectos sociais

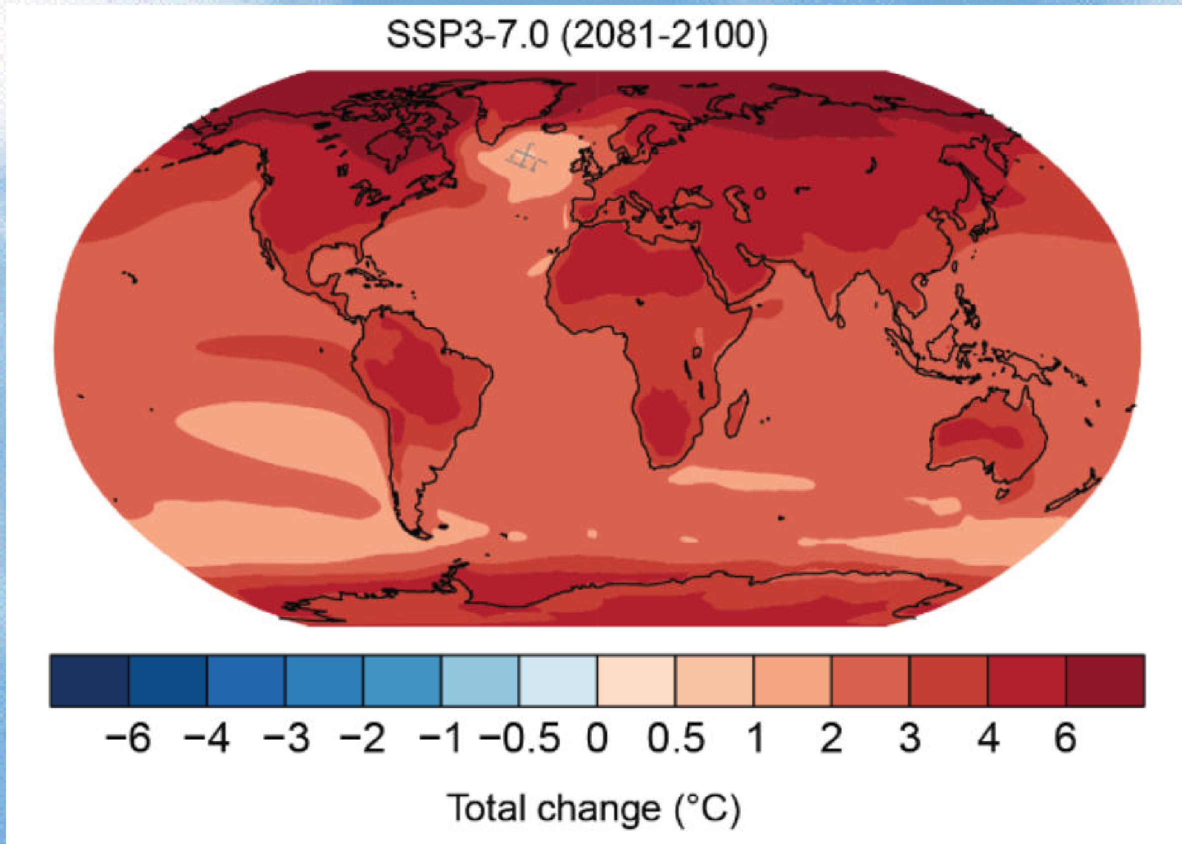


Precisamos de sólida ciência interdisciplinar para construir este espaço

Steffen et al. 2015, Science

Questões ambientais e climáticas impactarão cada vez mais na economia, no emprego e nas desigualdades sociais

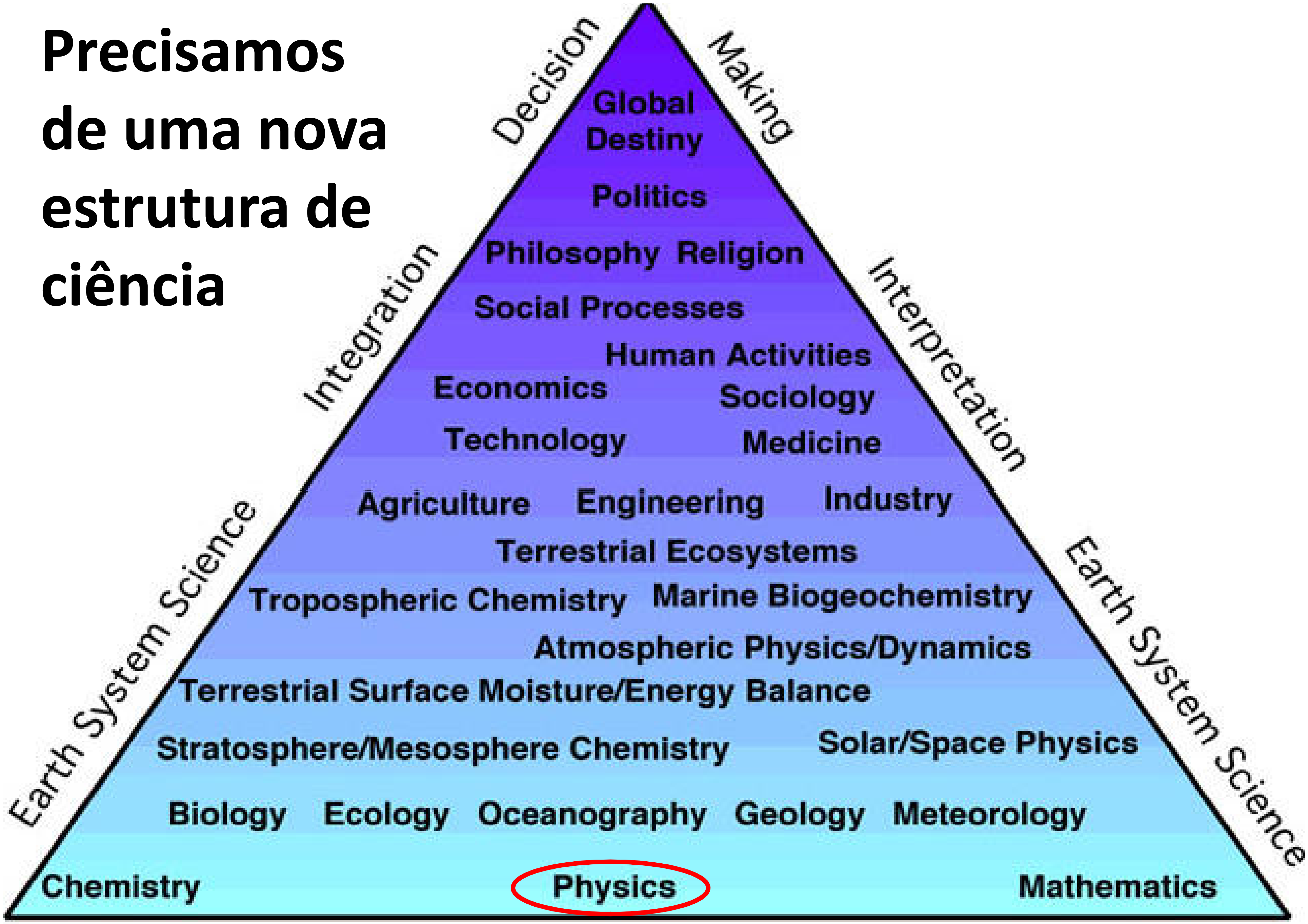
Benvindos ao novo clima de nosso planeta



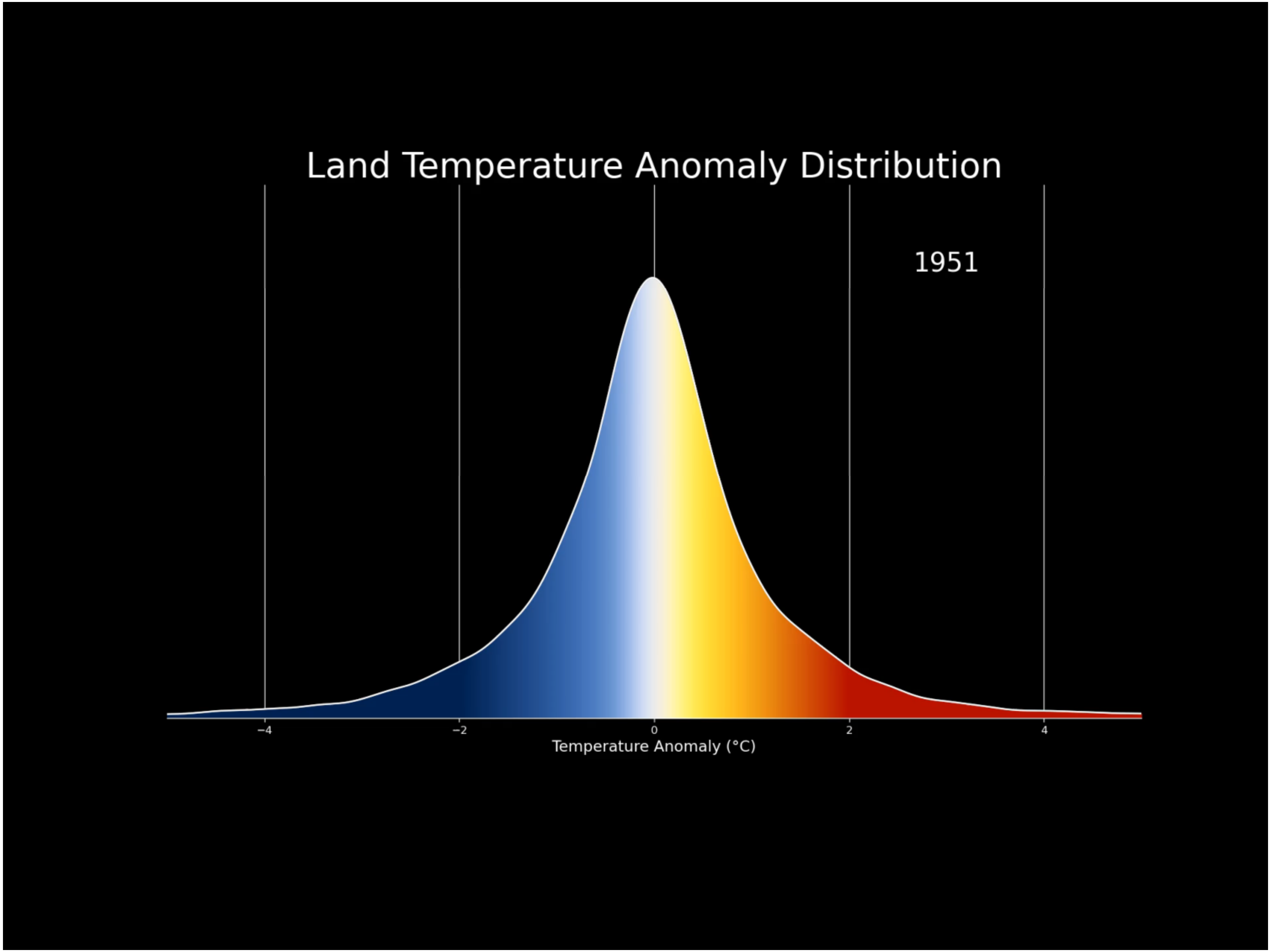
Obrigado pela atenção!!!

Paulo Artaxo – artaxo@if.usp.br

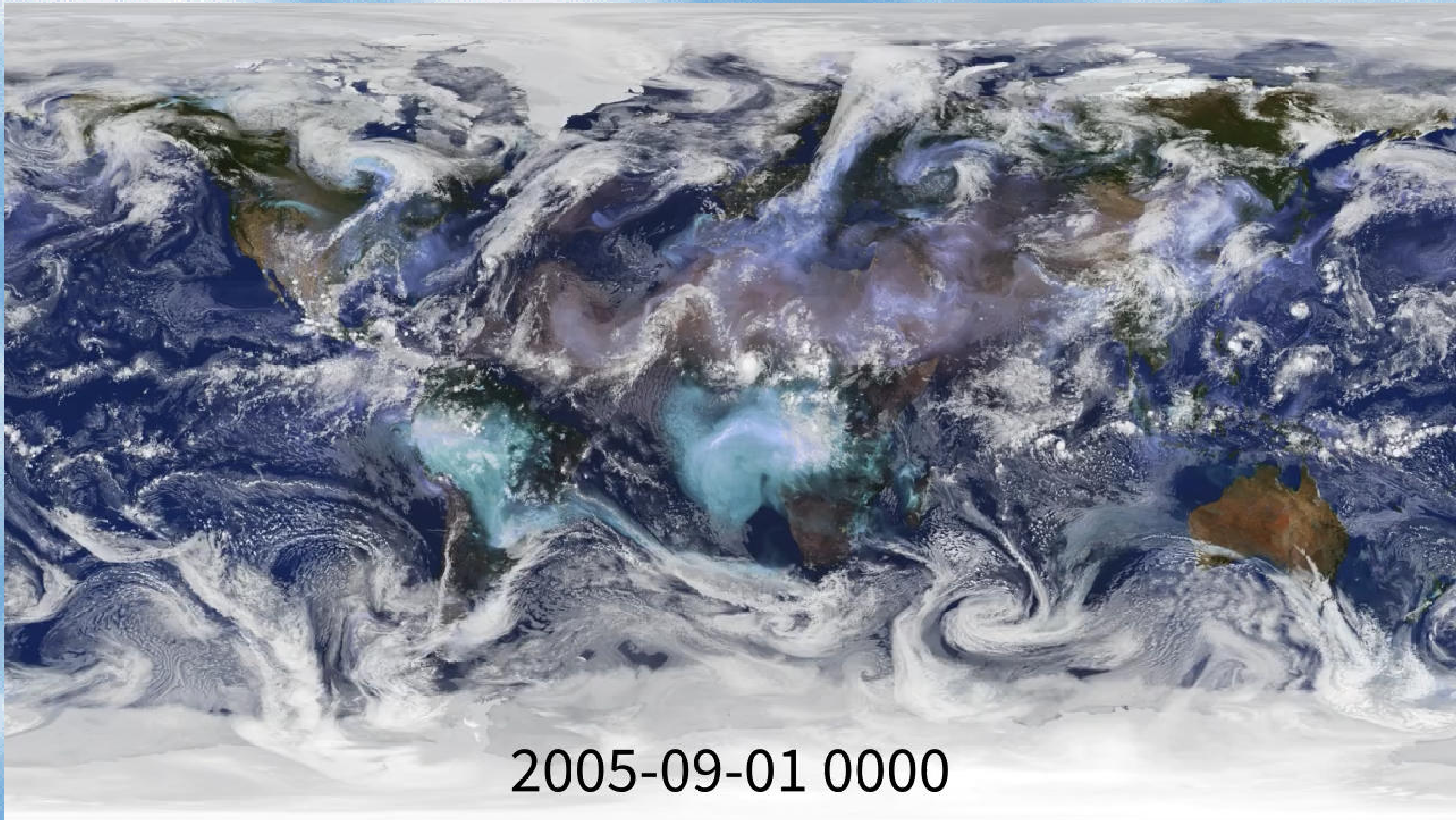
Precisamos de uma nova estrutura de ciência



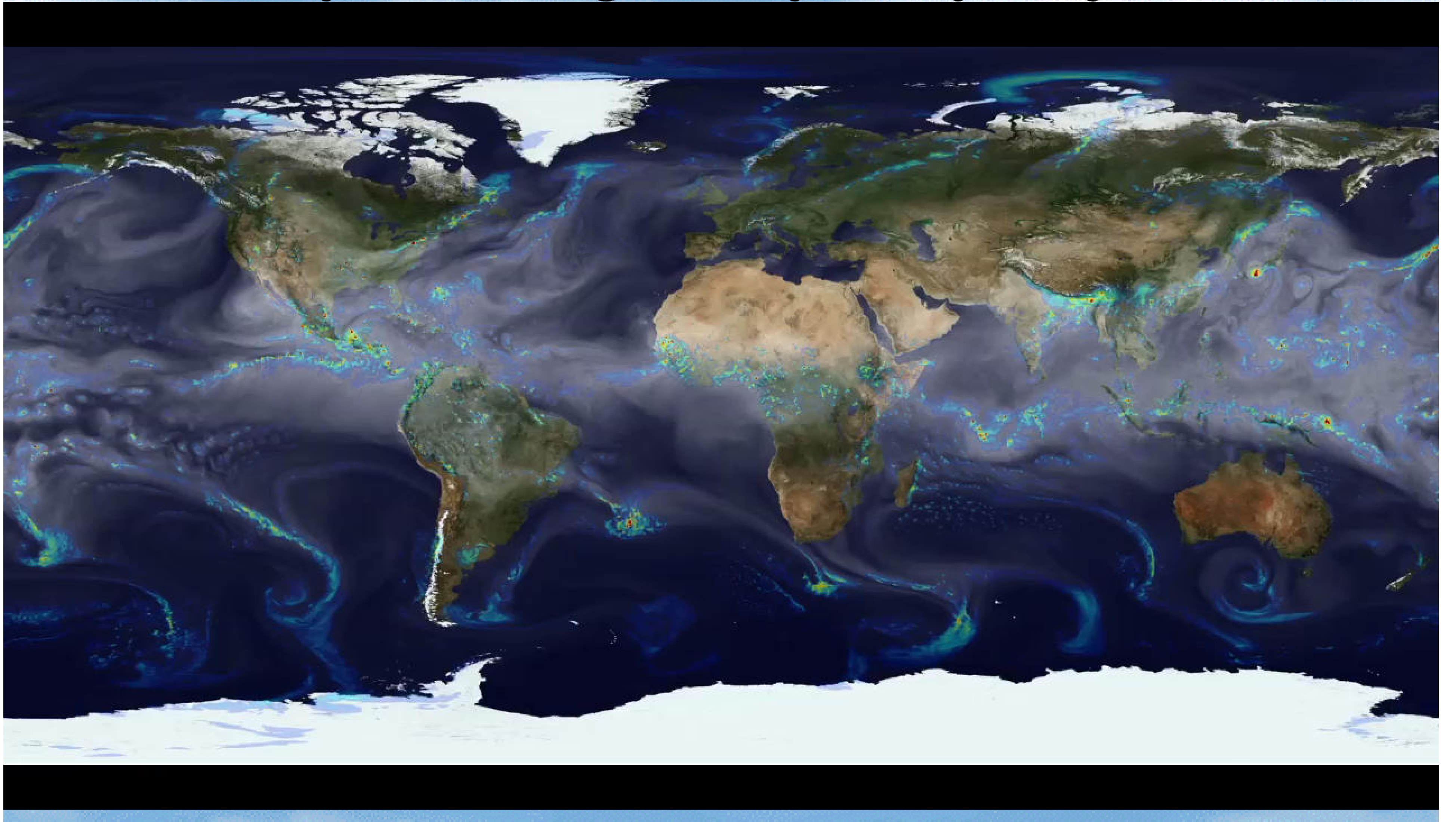
Ciência disciplinar em nossas universidades


Land Temperature Anomaly Distribution
1951
−4
−2
0
2
4
Temperature Anomaly (°C)

A complexidade das nuvens no sistema climático



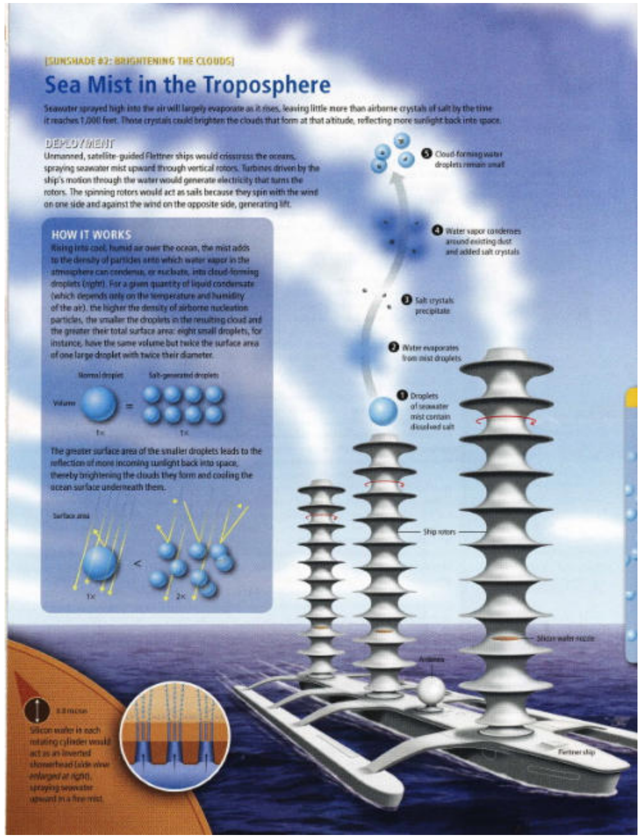
Vapor de água e precipitação

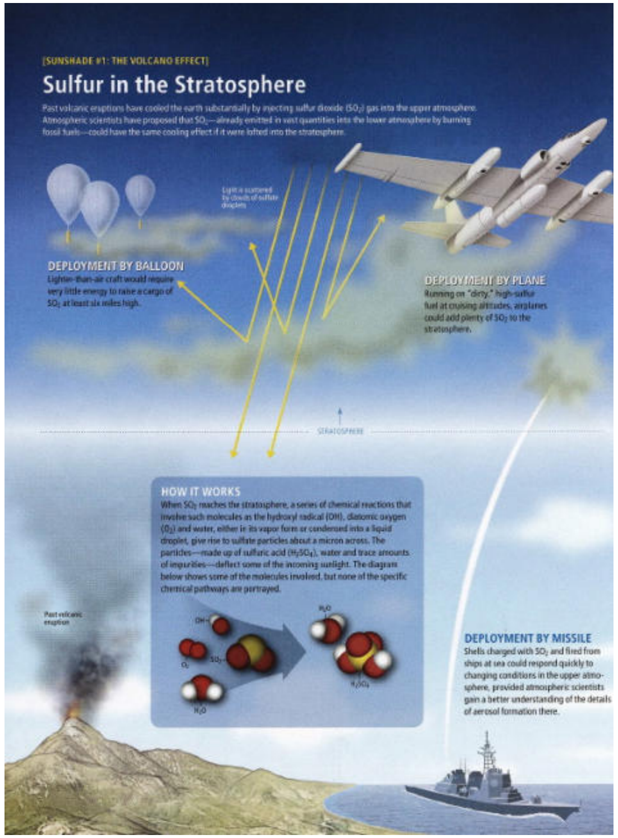


To study the effects of precipitation and how it influences other phenomena, scientists study moisture and precipitation in the atmosphere. Satellite observations cover broad areas and provide more frequent measurements that offer insights into when, where, and how much it rains or snows worldwide. Researchers 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.

Geoengenharia climática?
Possível? Desejável?

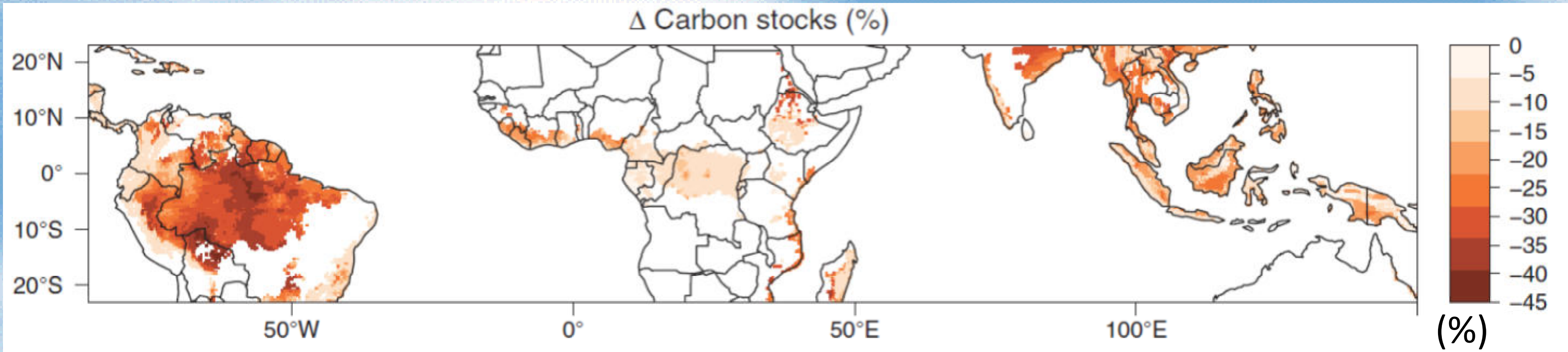
Espelhos no espaço? **Aumentar cobertura de nuvens?** **Enxofre na estratosfera?**

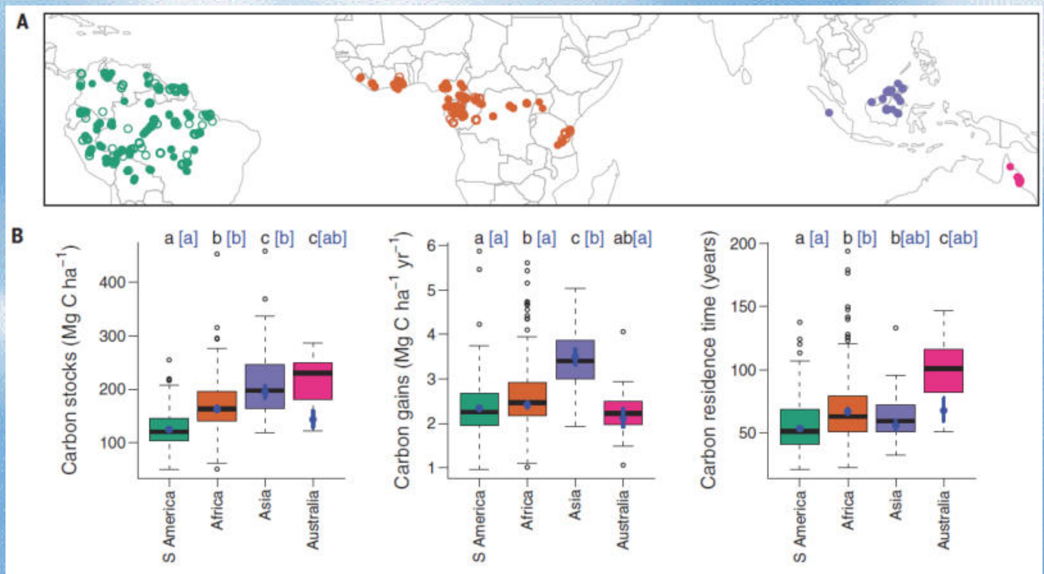




Long-term thermal sensitivity of Earth's tropical forests: Threshold: 32.2 °C.

Long-term change in carbon stocks due to temperature effects alone for global surface air temperature warming of 2°C





Spatial variation in tropical forest carbon.

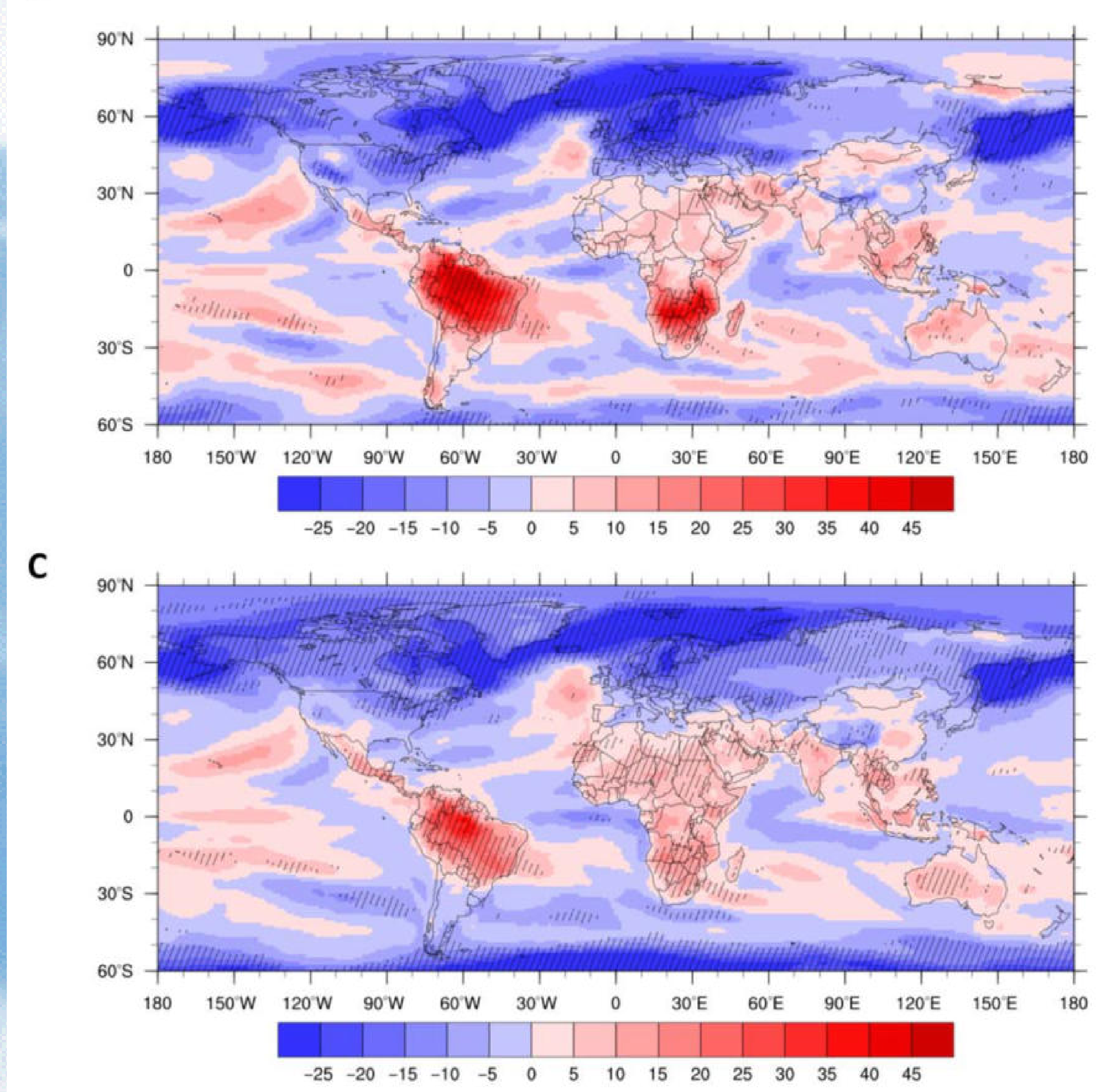
Sullivan et al., Science 368, 869–874 (2020)

Climate models predict increasing temperature variability in Amazonia

Relative changes of Standard Deviation of monthly temperature anomalies until the end of the 21st century

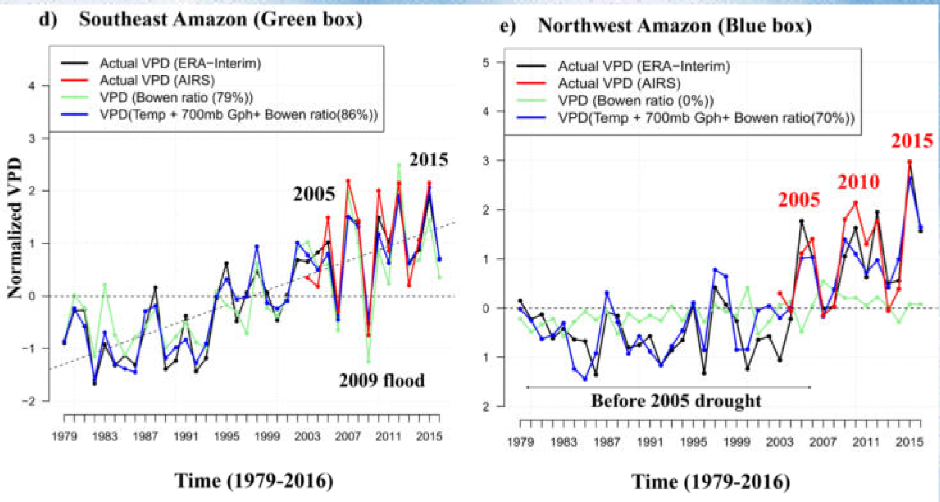
B) austral summer [DJF]

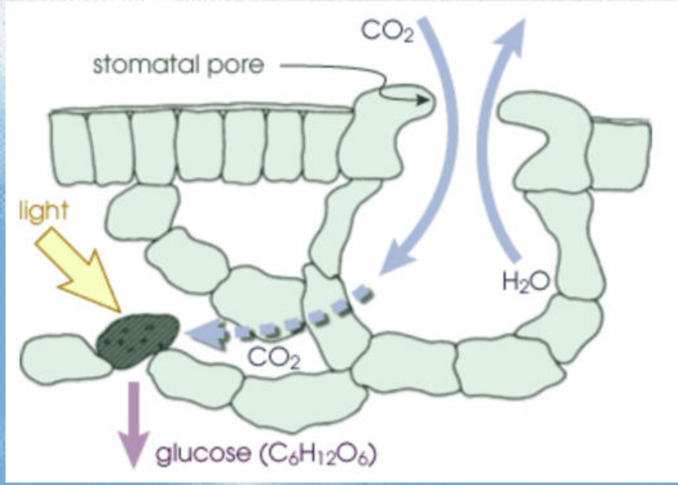
(C) the whole year



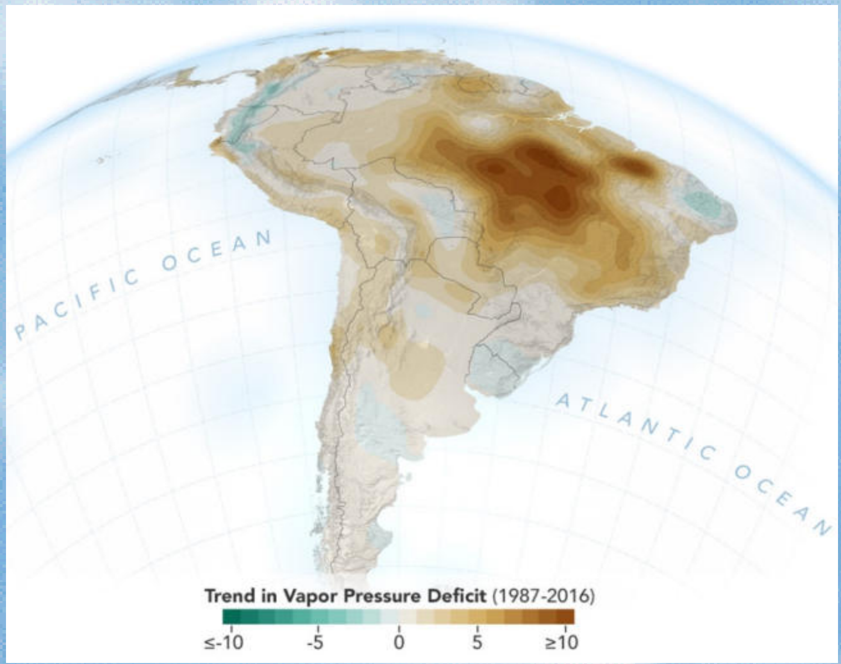
Bathiany et al., Sci. Adv. 2018;4: May 2018

Aumento no deficit de presssão de vapor : redução da evapotranspiração na 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

nature

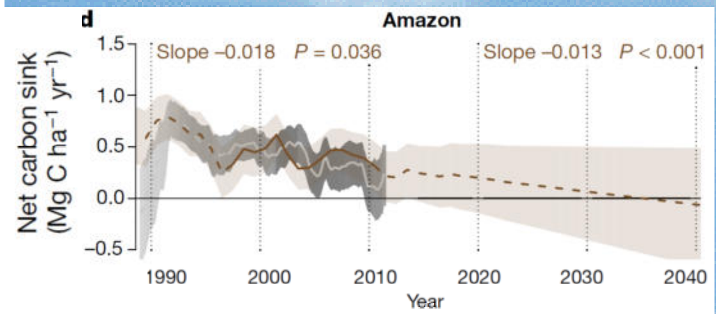
March 5, 2020

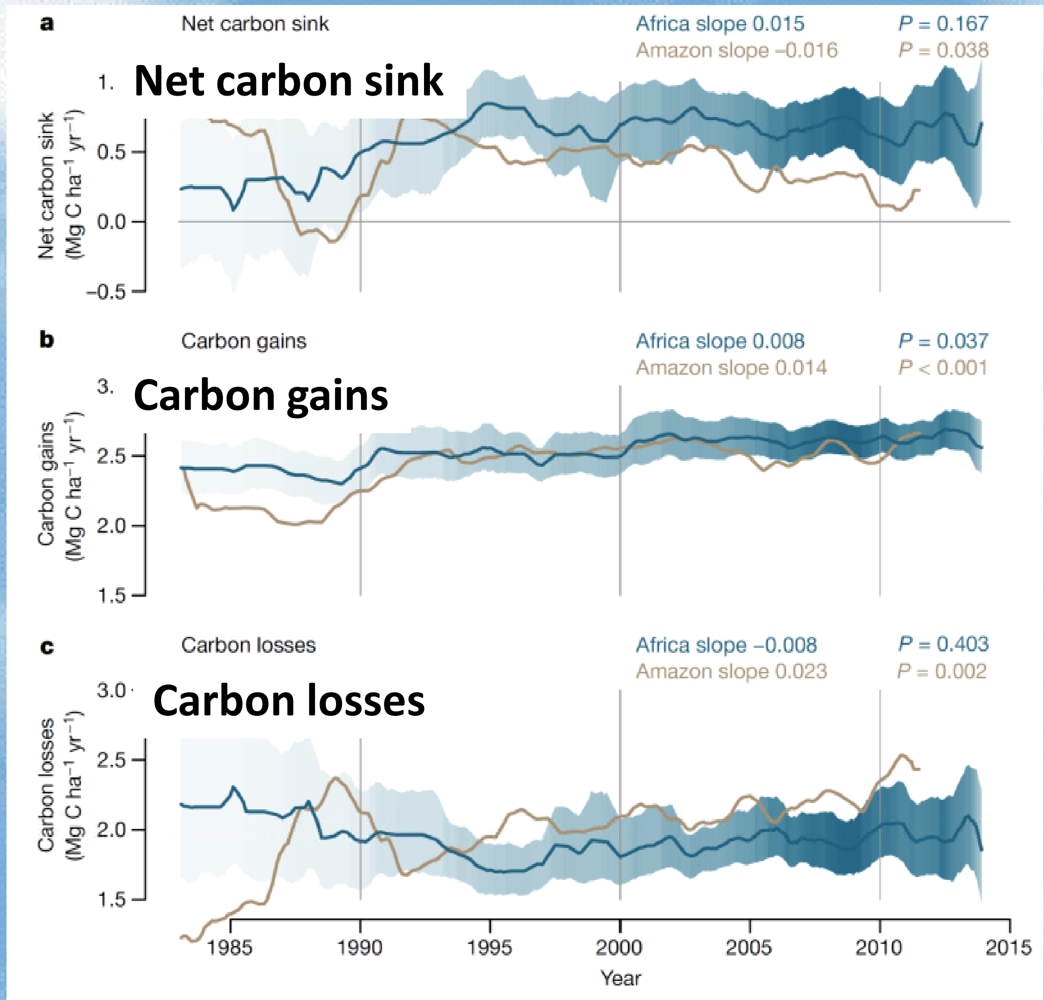
Article

Asynchronous carbon sink saturation in African and Amazonian tropical forests

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

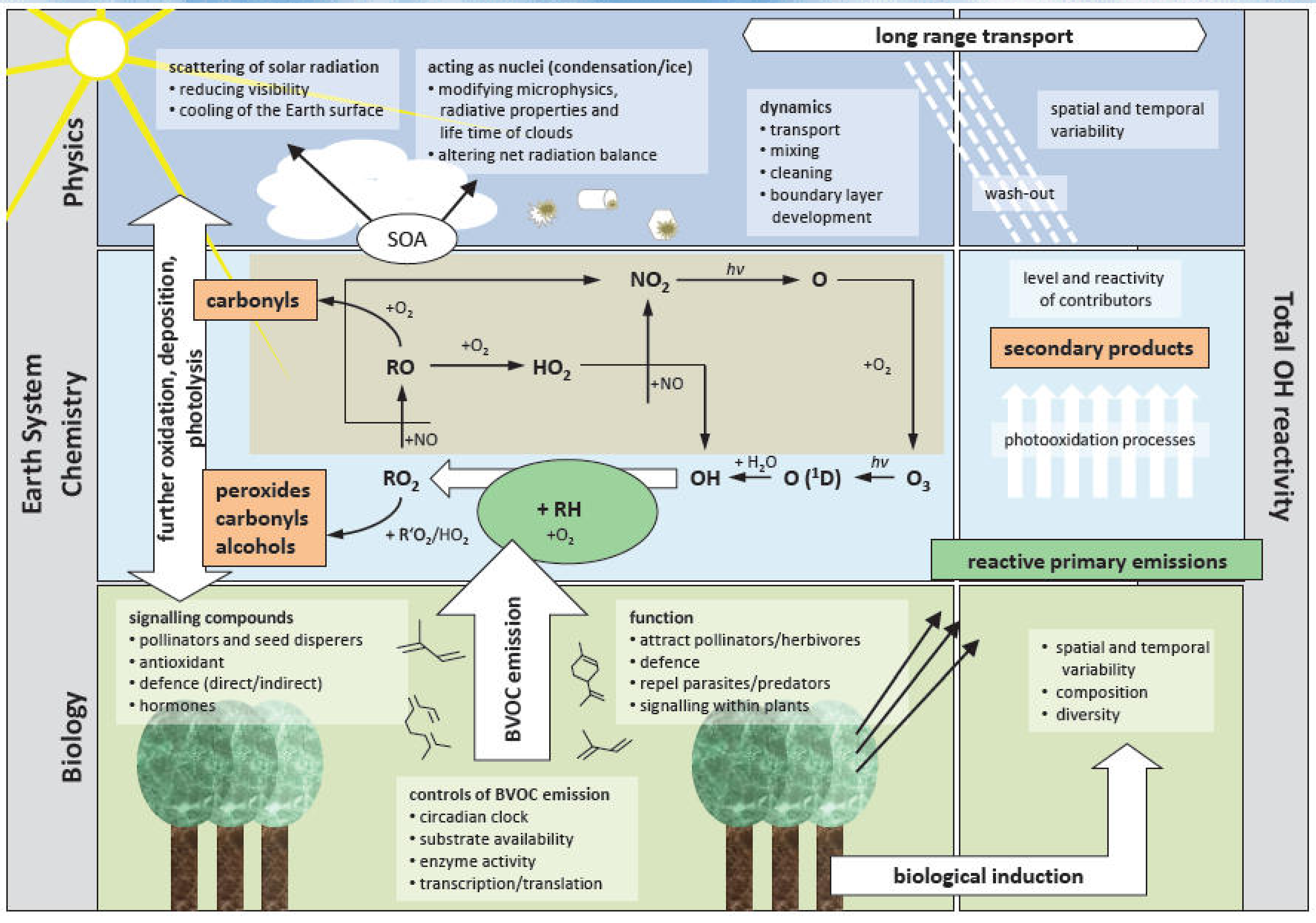
Net Carbon sink 1990-2040





Hubau et al., Nature 2020 doi:/10.1038/s41586-020-2035-0

Amazonia: Integrating biology, chemistry and physics



The IPCC WG3 report finds that:

•Governments are acting too slowly, held back by the lobbying efforts of fossil-fuel companies.

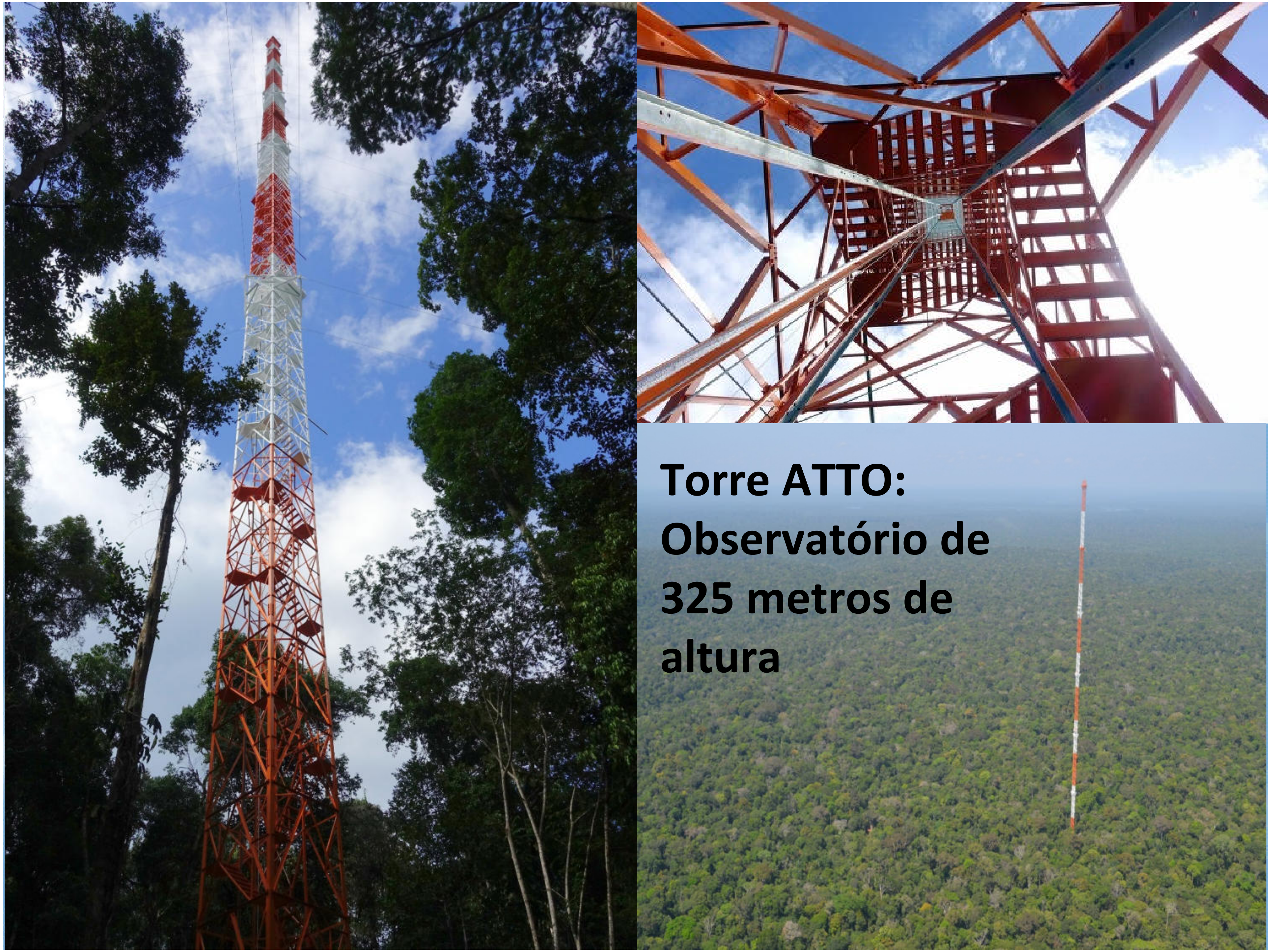
•Greenhouse-gas emissions continue to rise.

•Wealthy countries must lend a helping hand to the countries that contributed least to the problem but face the worst impacts.

•The good news:We have the renewable-energy technologies we need to make the change — and they are getting cheaper.

•It is possible to pull carbon pollution out of the atmosphere by expanding forests and improving agricultural practices.

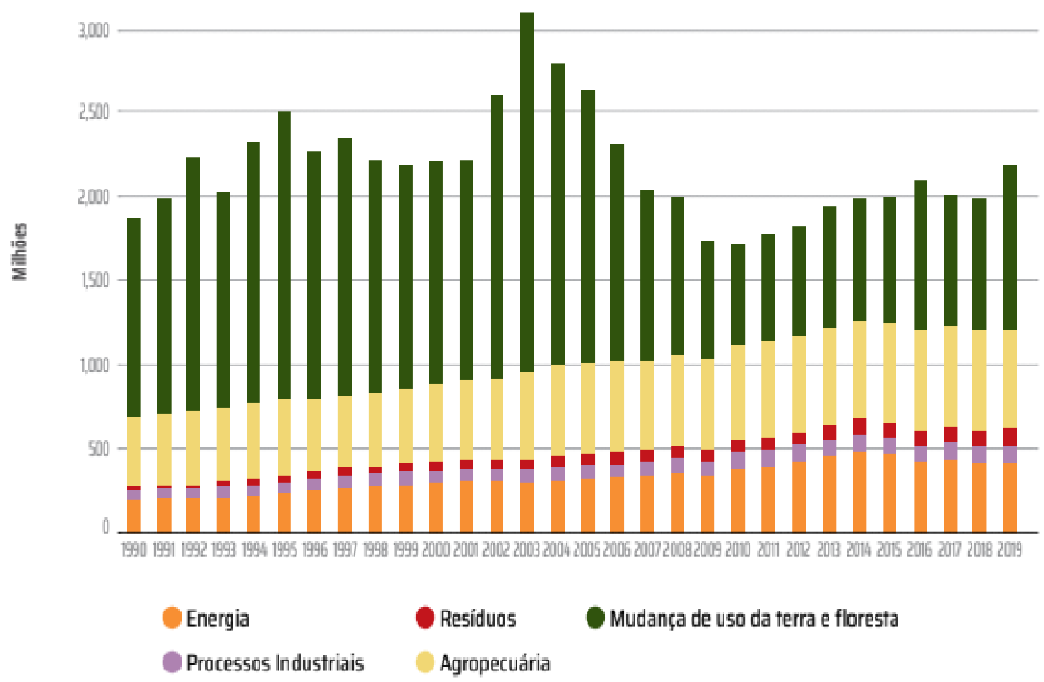
•The economic benefits of limiting warming — including improved health and reduced damages — exceed the cost of mitigation.

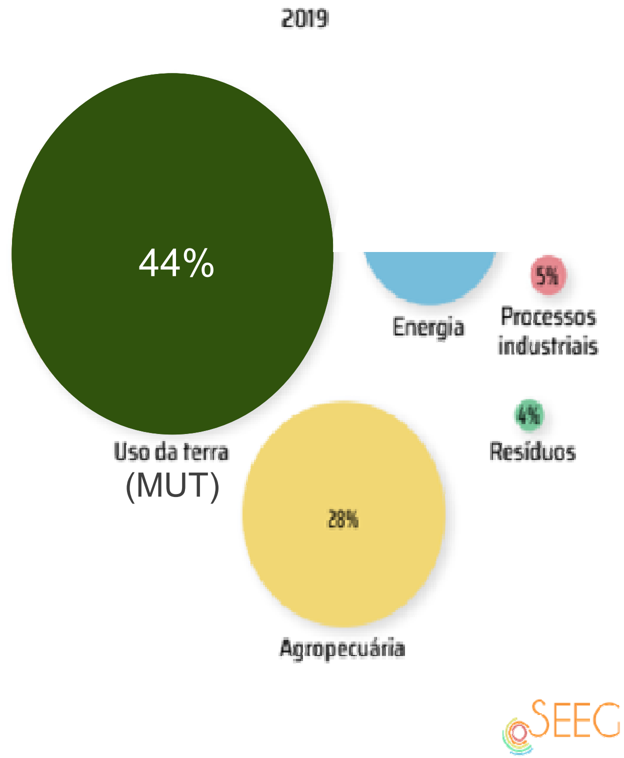


Torre ATTO: Observatório de 325 metros de altura

Emissões de GEE no Brasil (www.seeg.eco)

Mudança de uso da terra/ desmatamento foi responsável por

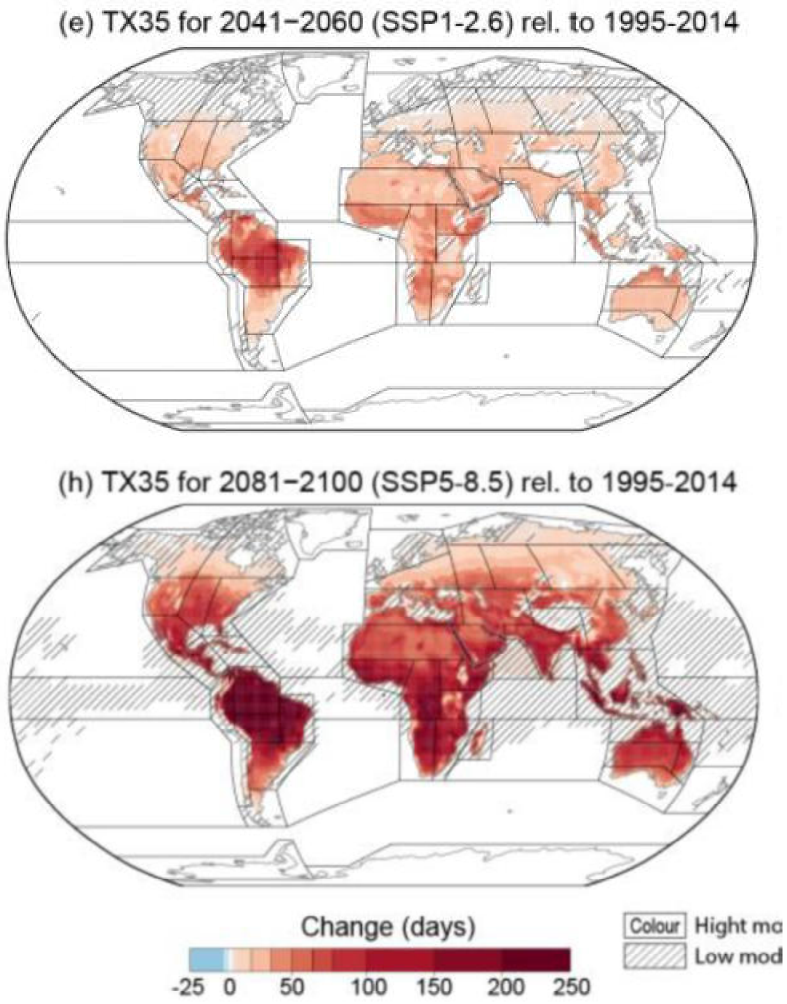




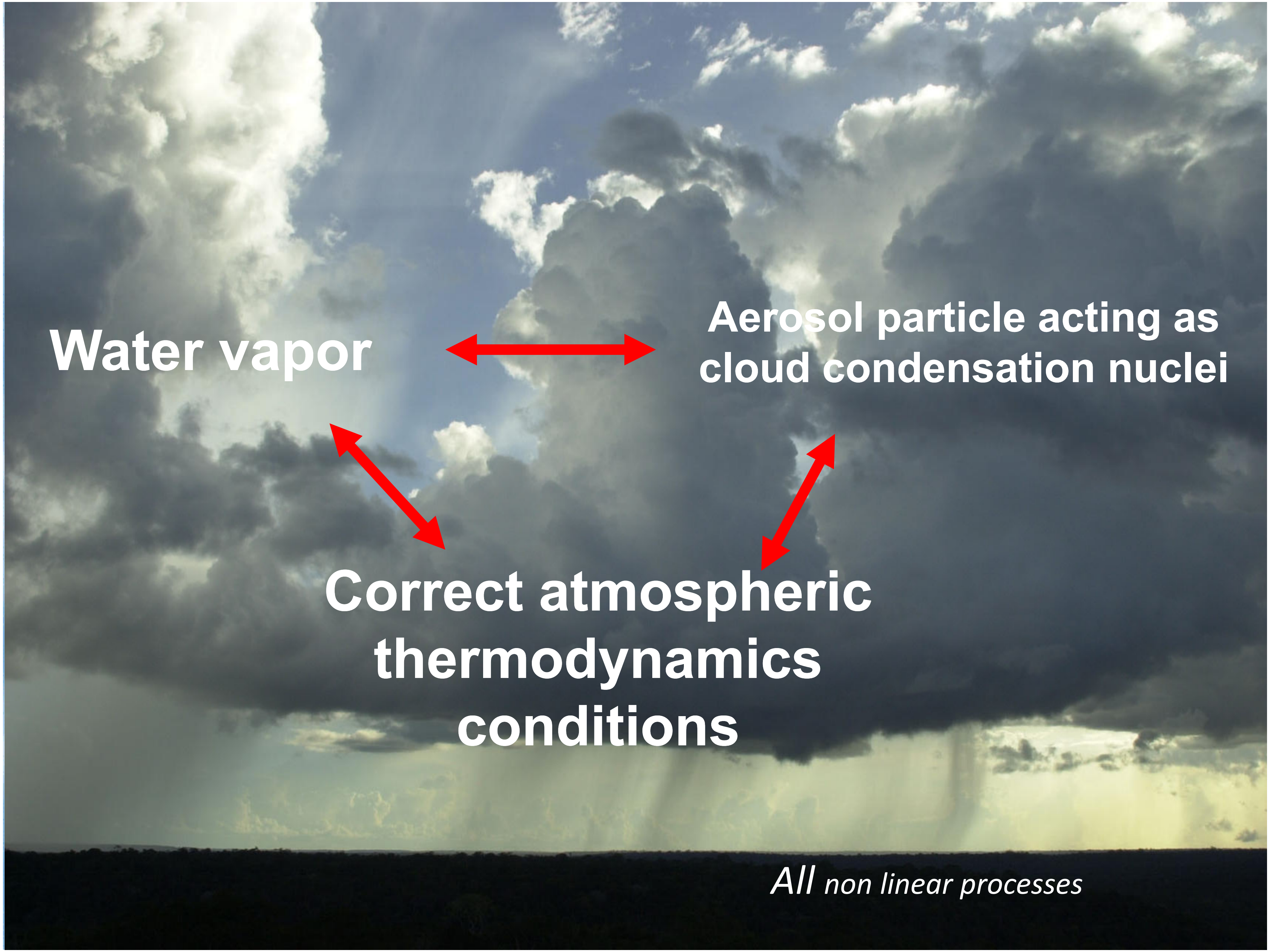
Cenário 2.6

Número de dias por ano com temperatura máxima passando de 35 graus

Cenário 8.5

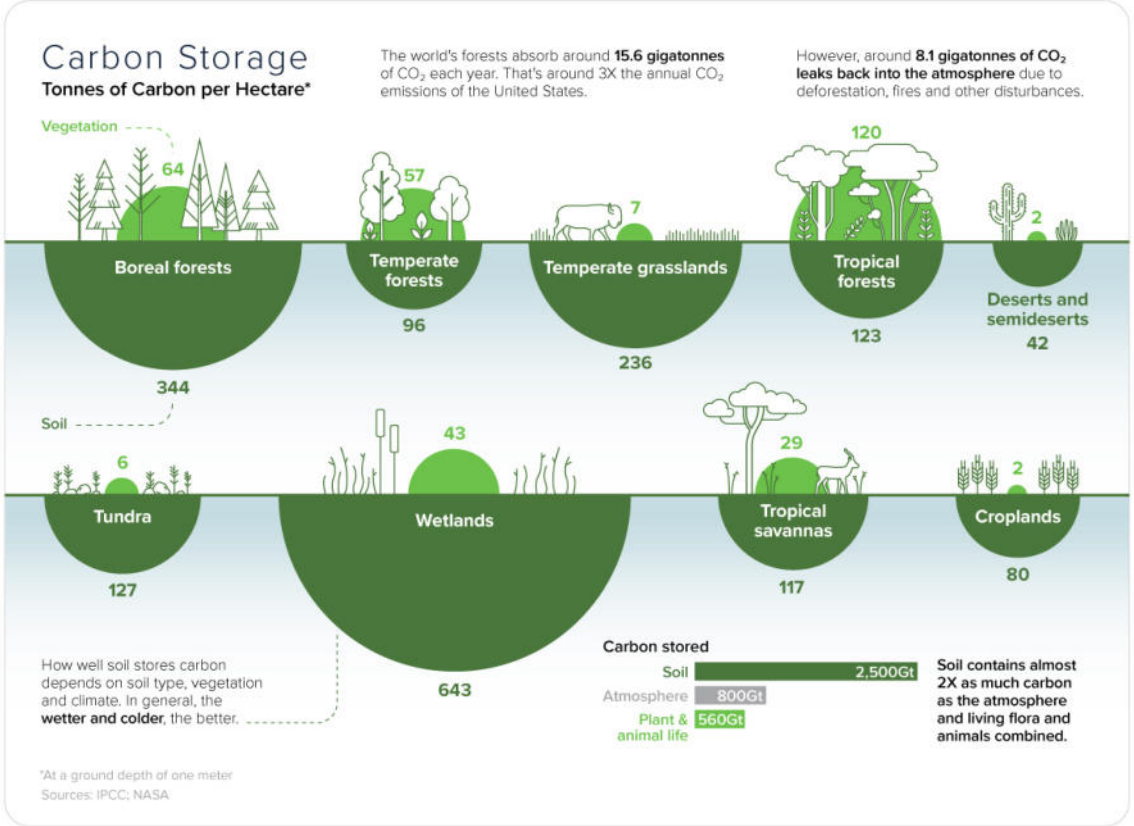


Simulações CMIP6


Water vapor
Aerosol particle acting as cloud condensation nuclei
Correct atmospheric thermodynamics conditions
All non linear processes

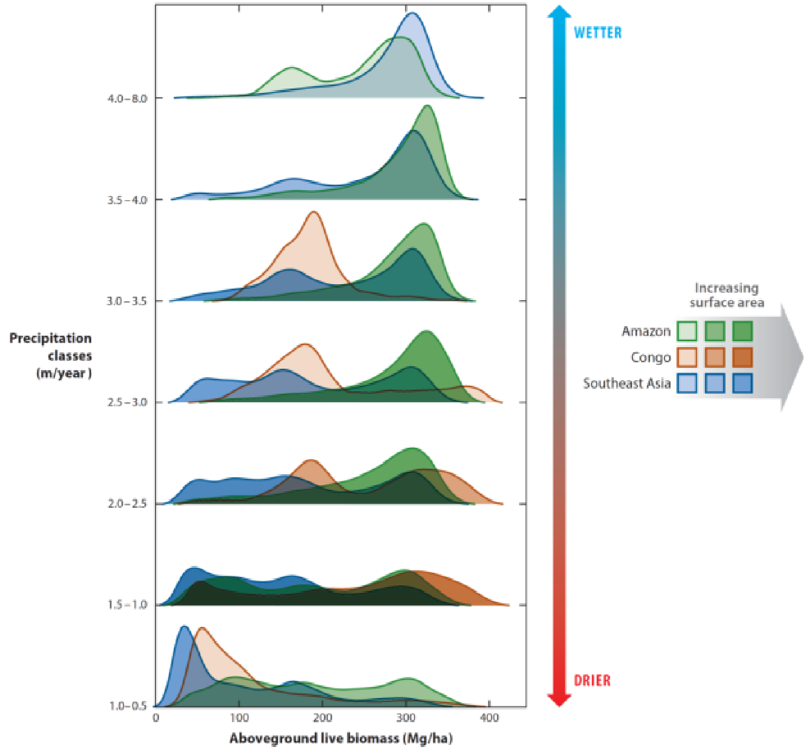
O armazenamento de carbono nos ecossistemas terrestres

Atingir net zero in 2050 vai depender dos sumidouros de carbono naturais



Carbon versus precipitation

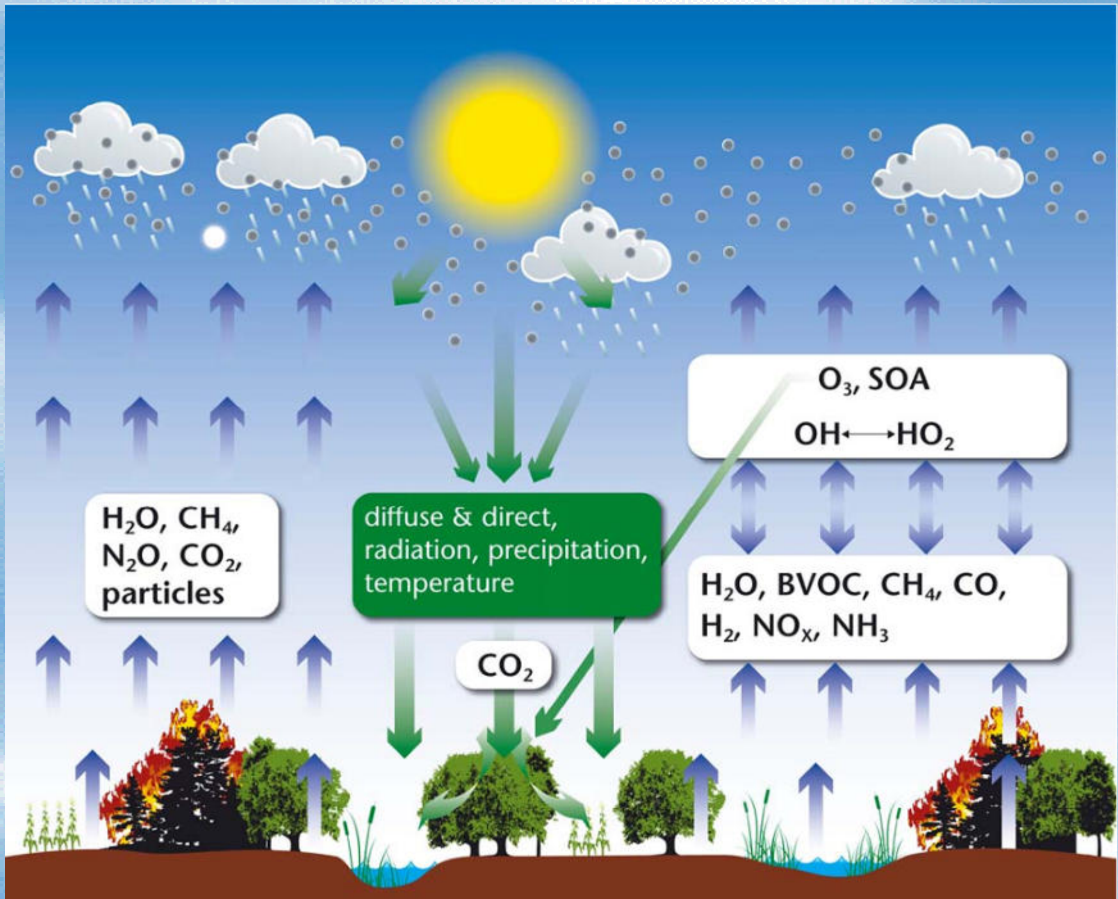
Amazon, Congo Basin, and Southeast Asia



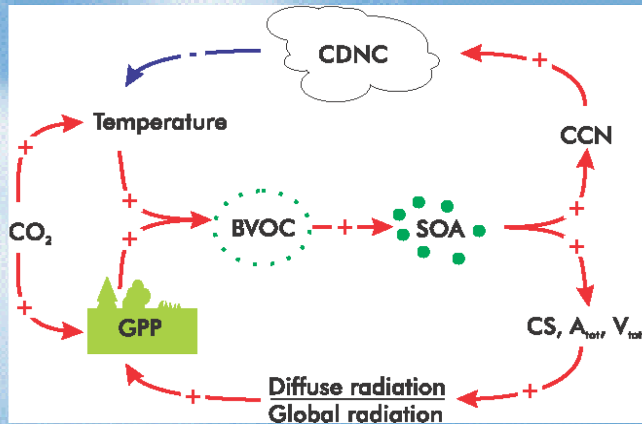
Paulo Brando et al., Annu. Rev. Earth Planet. Sci. 2019. 47:555–81

Carbon and hydrological cycles closely linked

Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions

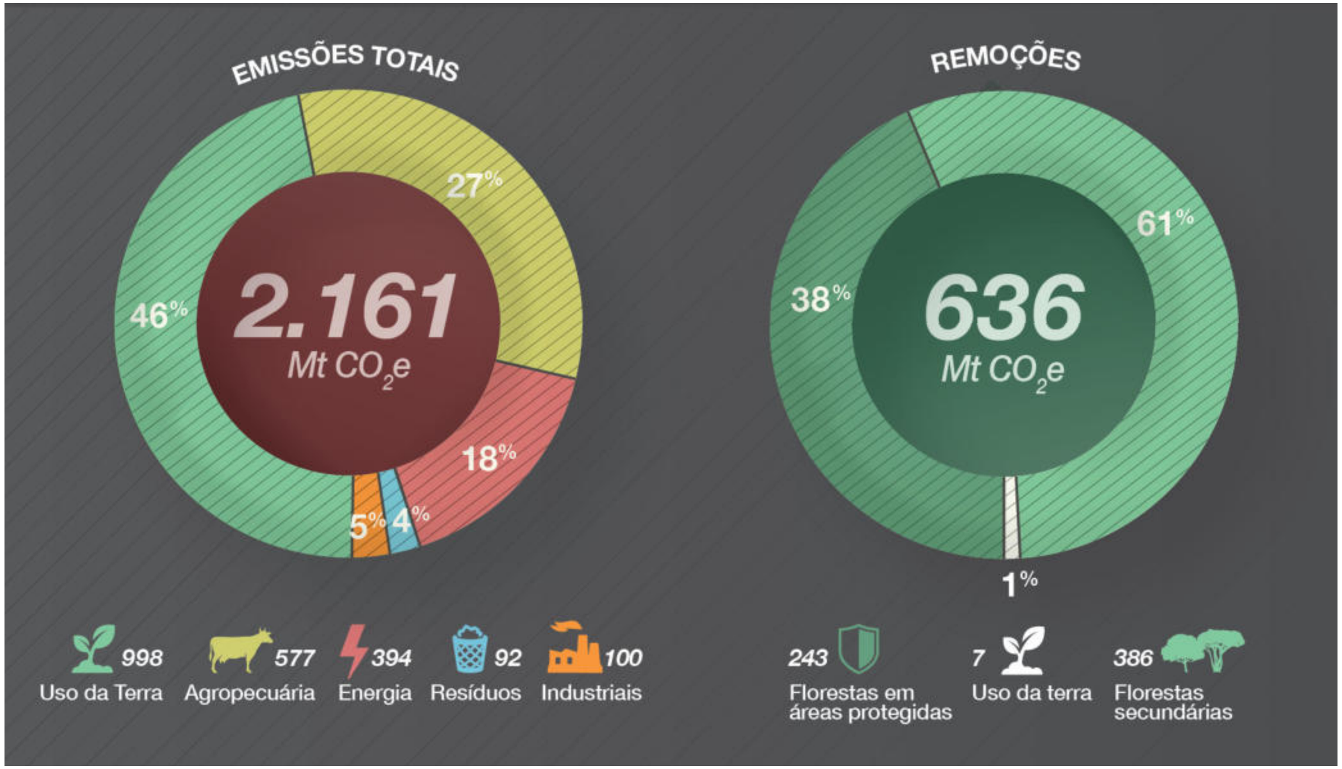


Arneth et al., 2011



Kulmala et al, 2013

Estimativas de emissões e remoções de gases de efeito estufa do Brasil – SEEG 2020



http://seeg.eco.br/infografico

Evidências Impactos, Vulnerabilidades e Adaptação

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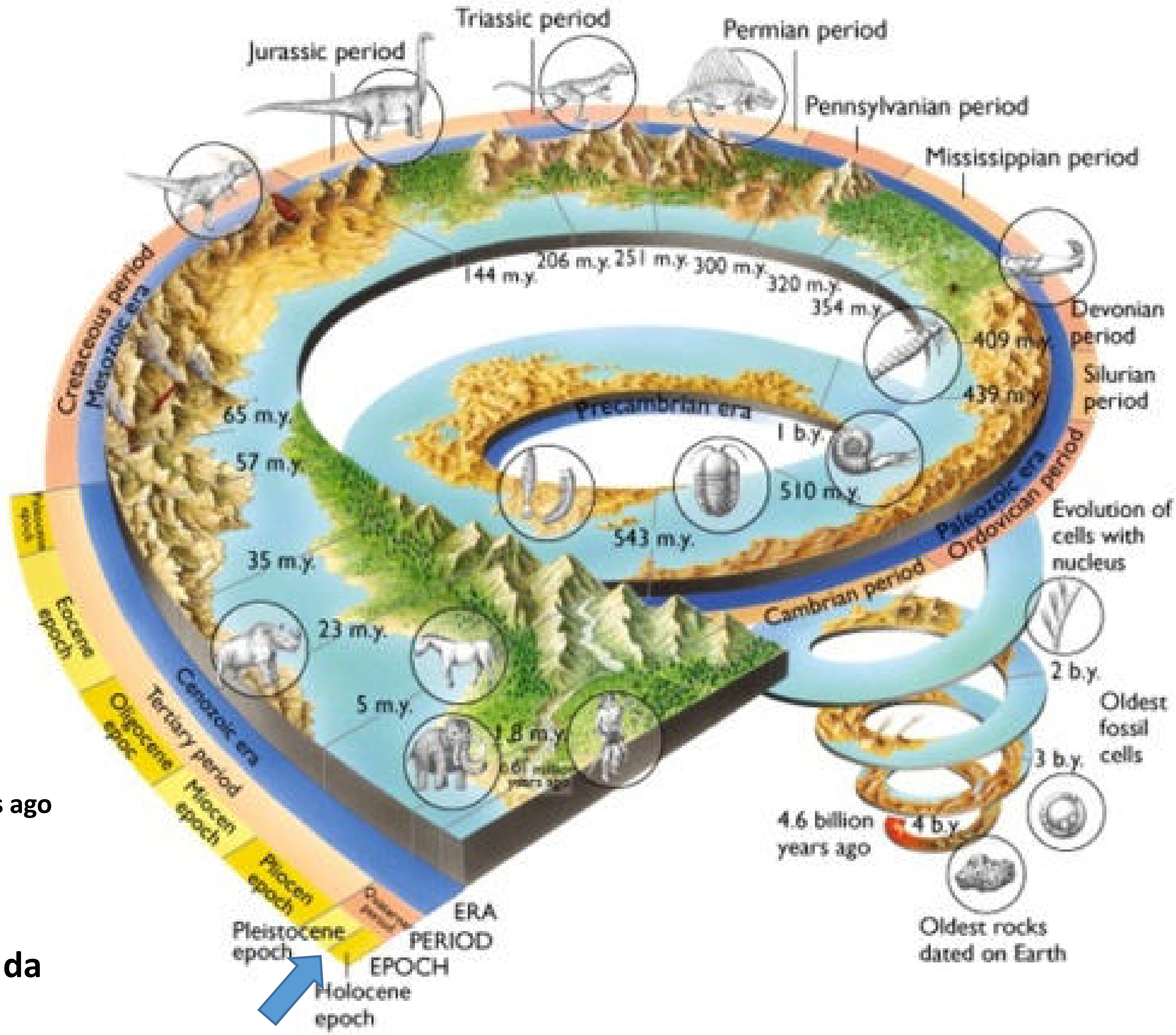
- Pontos de Inflexões Sociais (Social tipping Point)
- Riscos Residuais (Perdas e Danos)

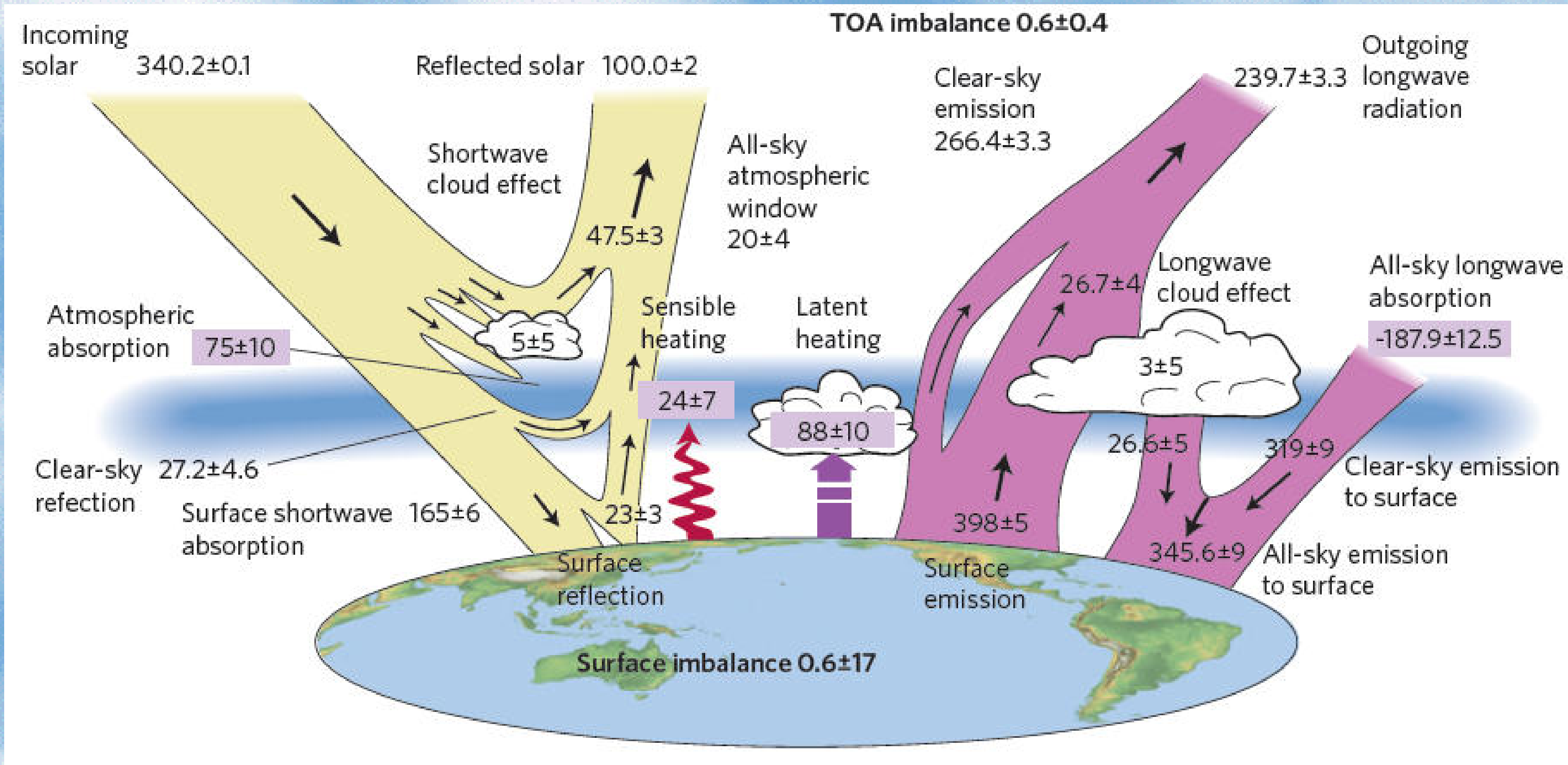
A evolução conjunta da Vida e da Geologia em nosso planeta



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

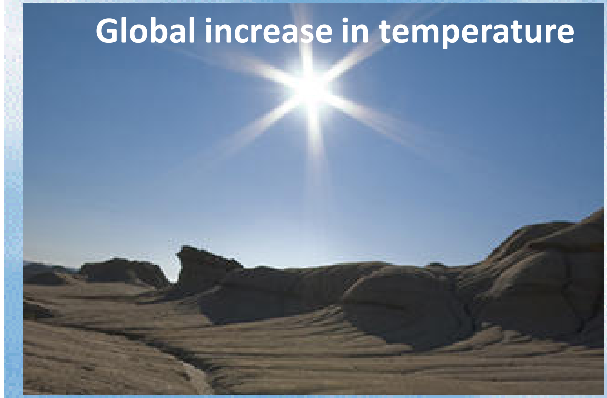
Os humanos estão presents somente no ultimo segundo da história de nosso planeta

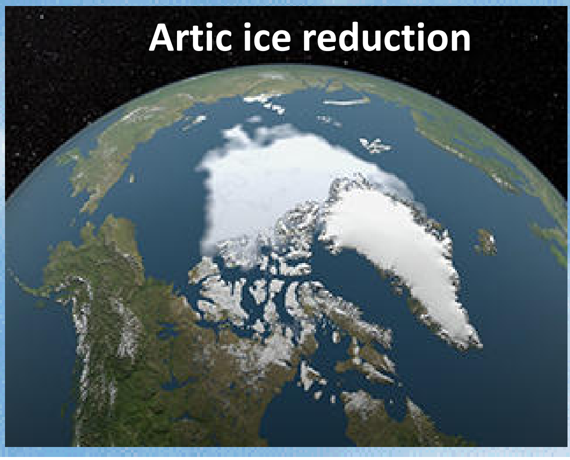
Balanço de energia do nosso planeta (W/m²)

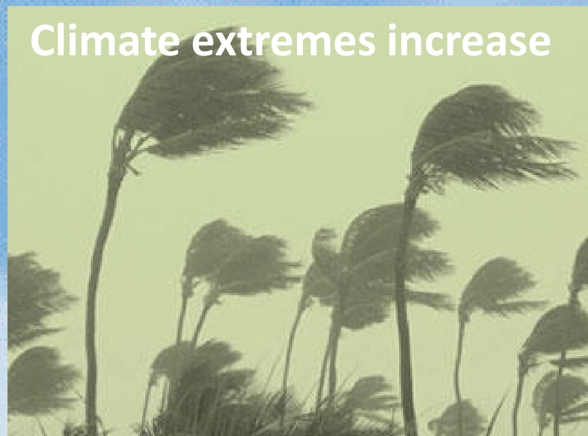


The global annual mean energy budget of Earth for the approximate period 2000–2010. All fluxes are in Wm^{-2}. (Stephens, Nature 2012)

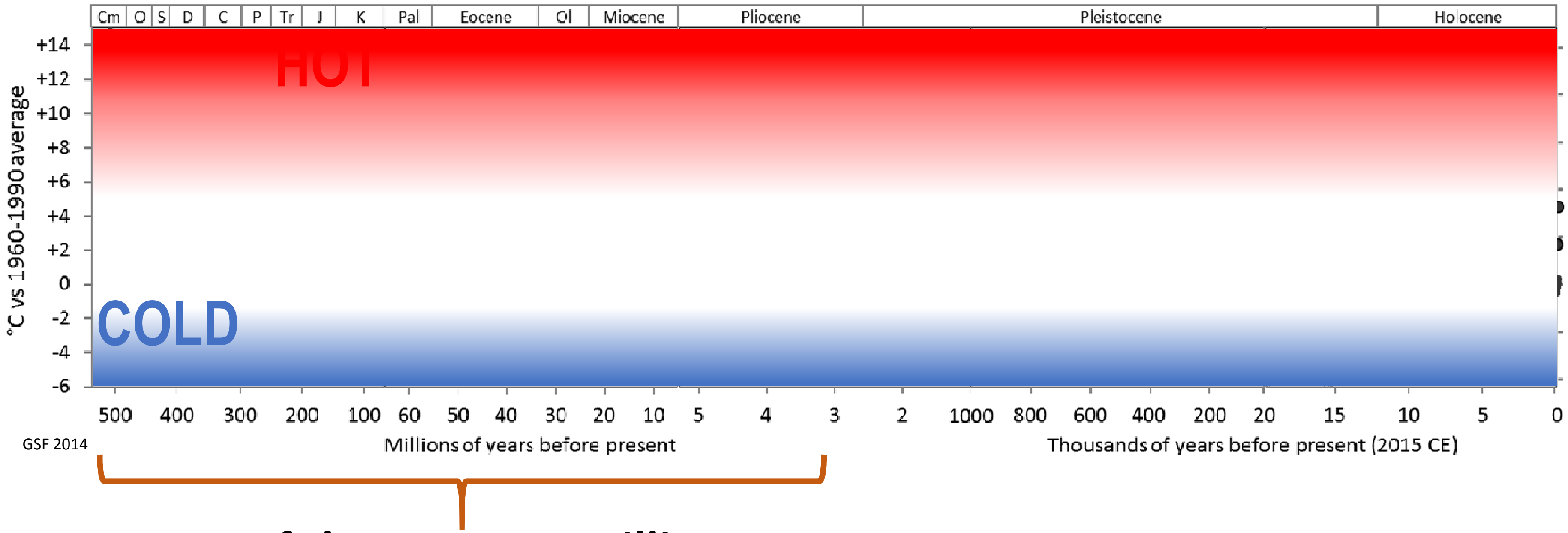
Evidencias de rápidas mudanças climáticas







What is the ‘state’ of our planet?

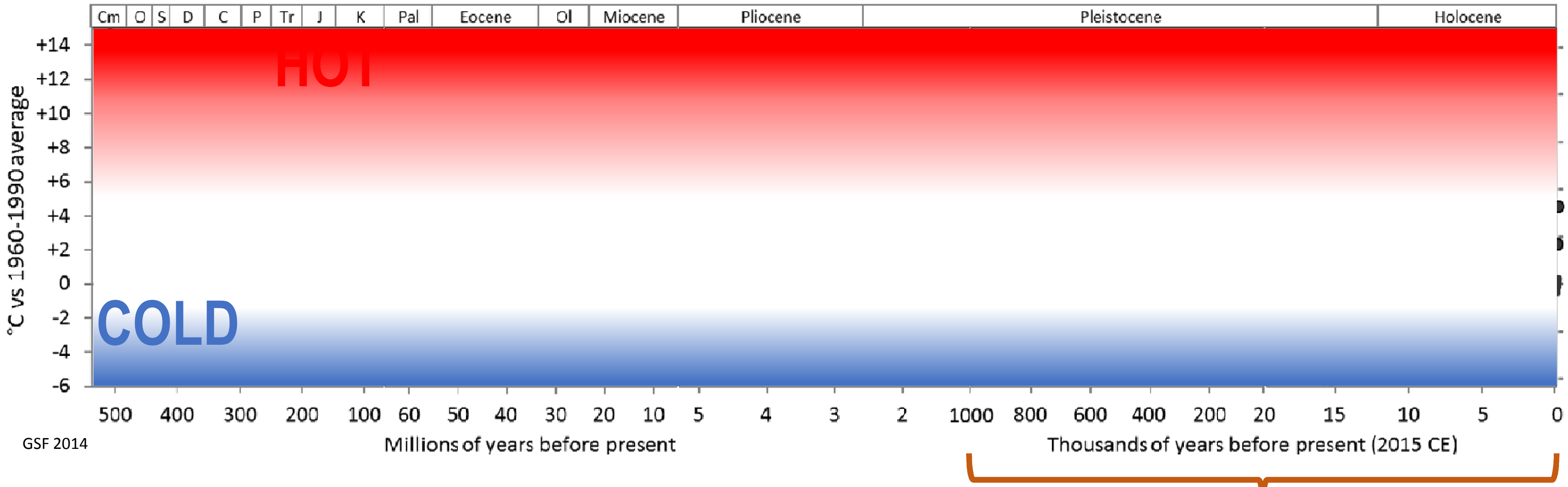


For most of the past 500 million years, Earth has been hotter than today

Figure adapted from data compilation G. Fergus 2007/2014, https://en.wikipedia.org/wiki/File:All_palaeotemps.png

See also: http://www.realclimate.org/index.php/archives/2014/03/can-we-make-better-graphs-of-global-temperature-history

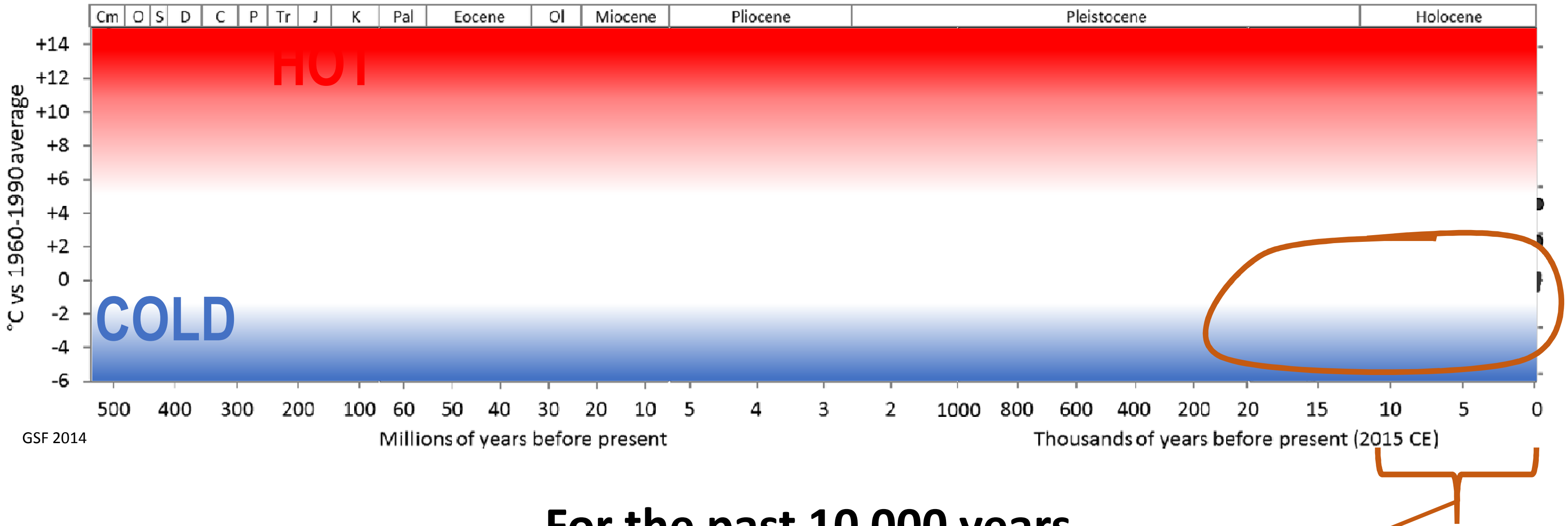
What is the 'state' of our planet?



For the past ~million years,
Earth has oscillated between ice-ages
and warm interglacial periods

Figure adapted from data compilation G. Fergus 2007/2014, https://en.wikipedia.org/wiki/File:All_palaeotemps.png

What is the 'state' of our planet?

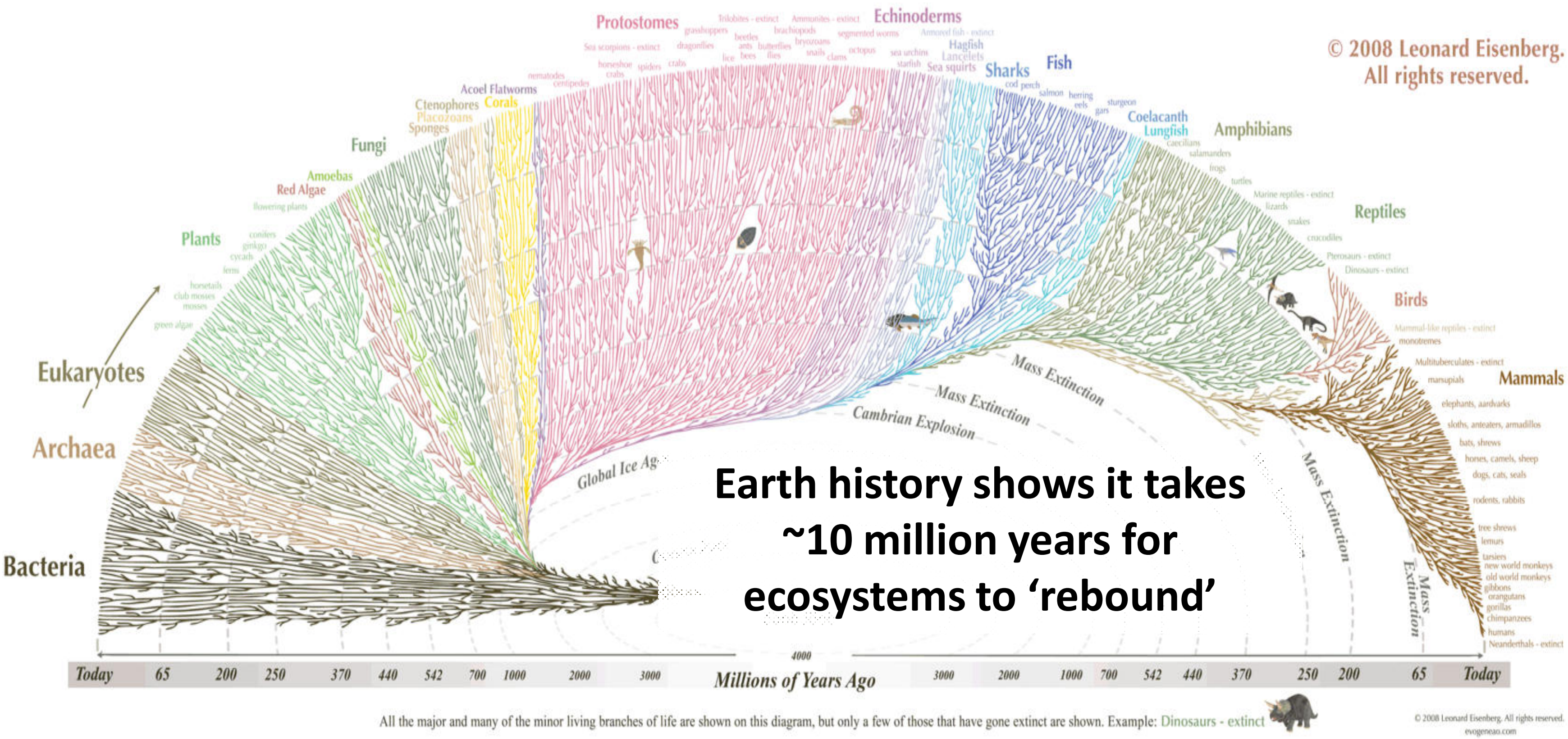


For the past 10 000 years, Earth's climate and ecosystems have been comparatively stable

Figure adapted from data compilation G. Fergus 2007/2014, https://en.wikipedia.org/wiki/File:All_palaeotemps.png

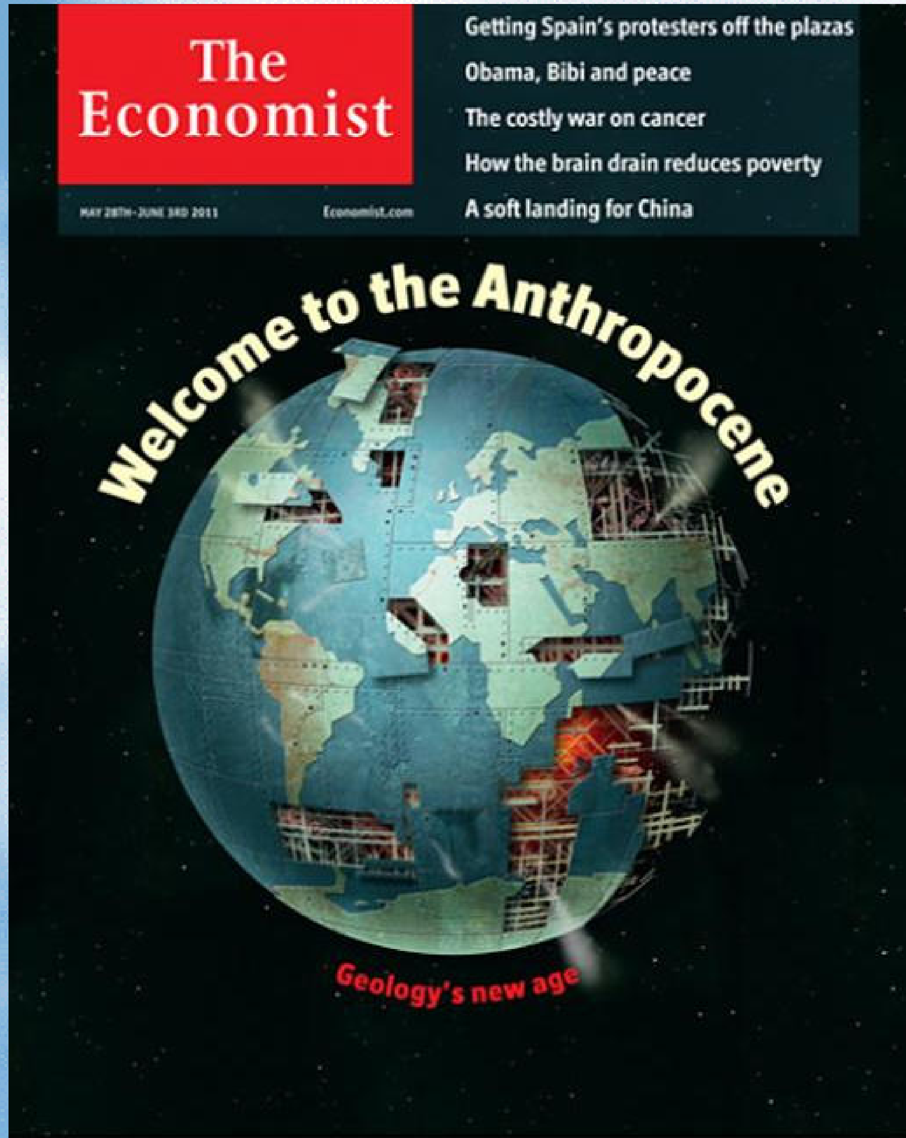
What does Earth system change mean?

Lowery and Fraass 2019, https://doi.org/10.1038/s41559-019-0835-0



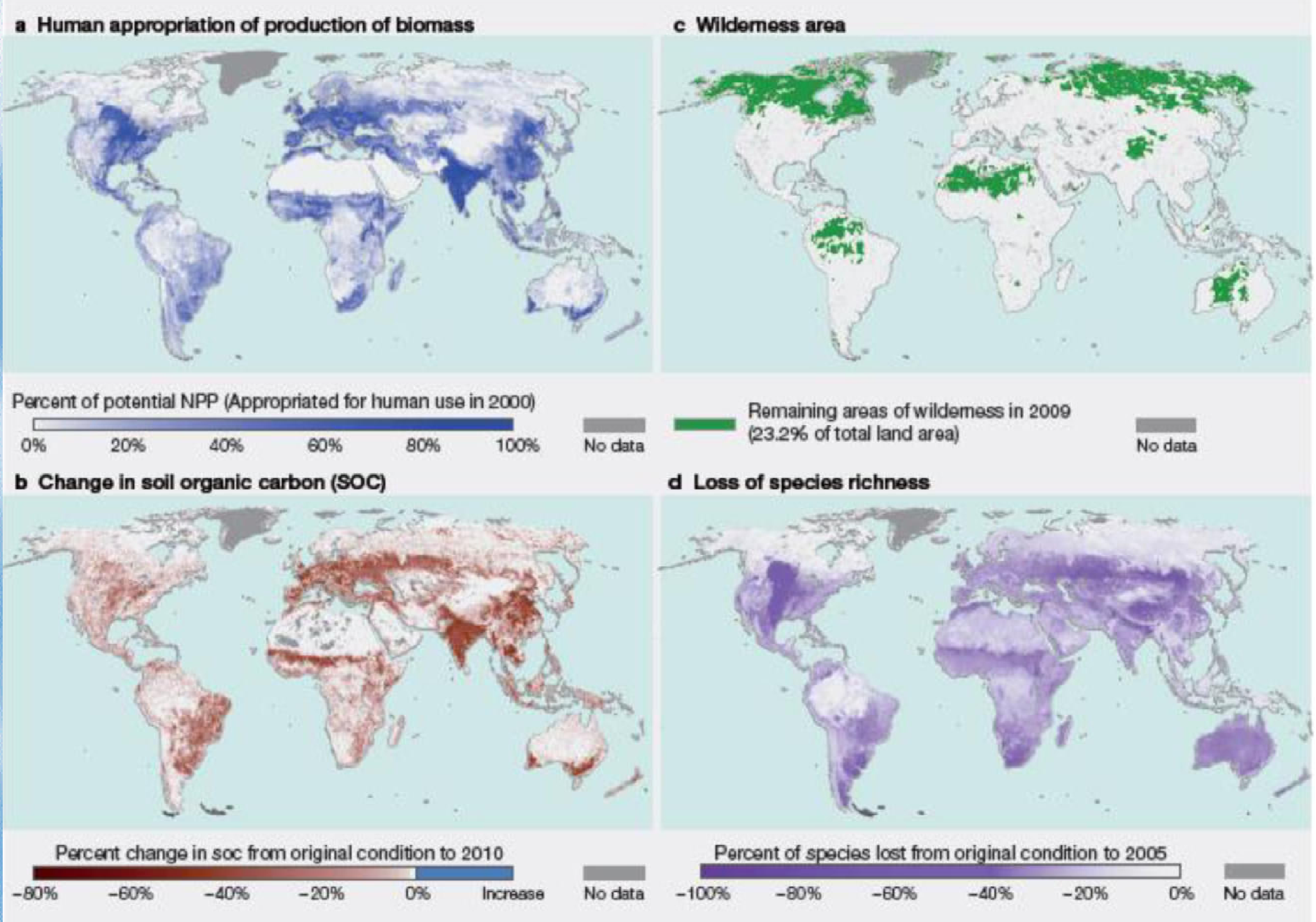
Earth history shows it takes ~10 million years for ecosystems to 'rebound'

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



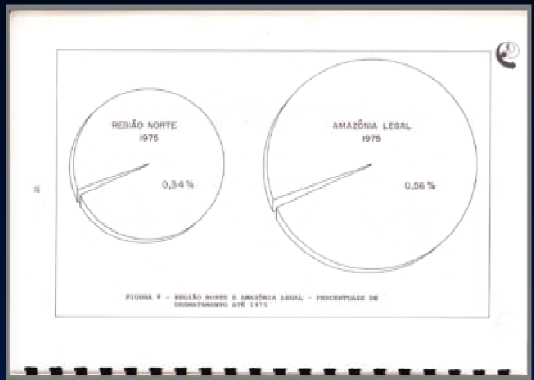
The Economist, 2011

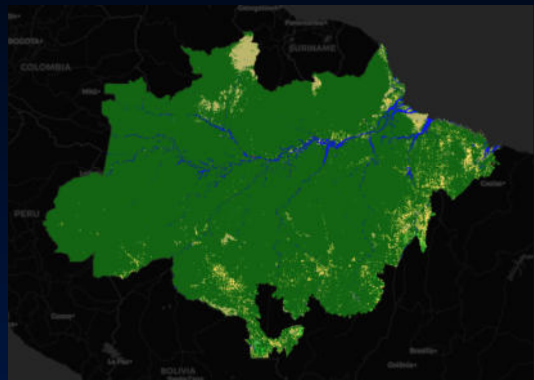
Impacto da atividade humana no planeta

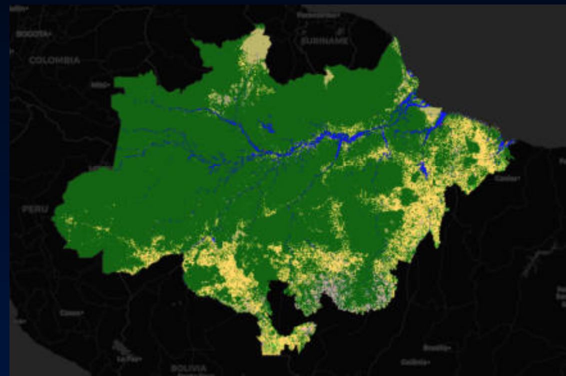


IPBES, 2018

Evolution of deforestation in Amazonia 1975-2018







1975

0,5 %

1988

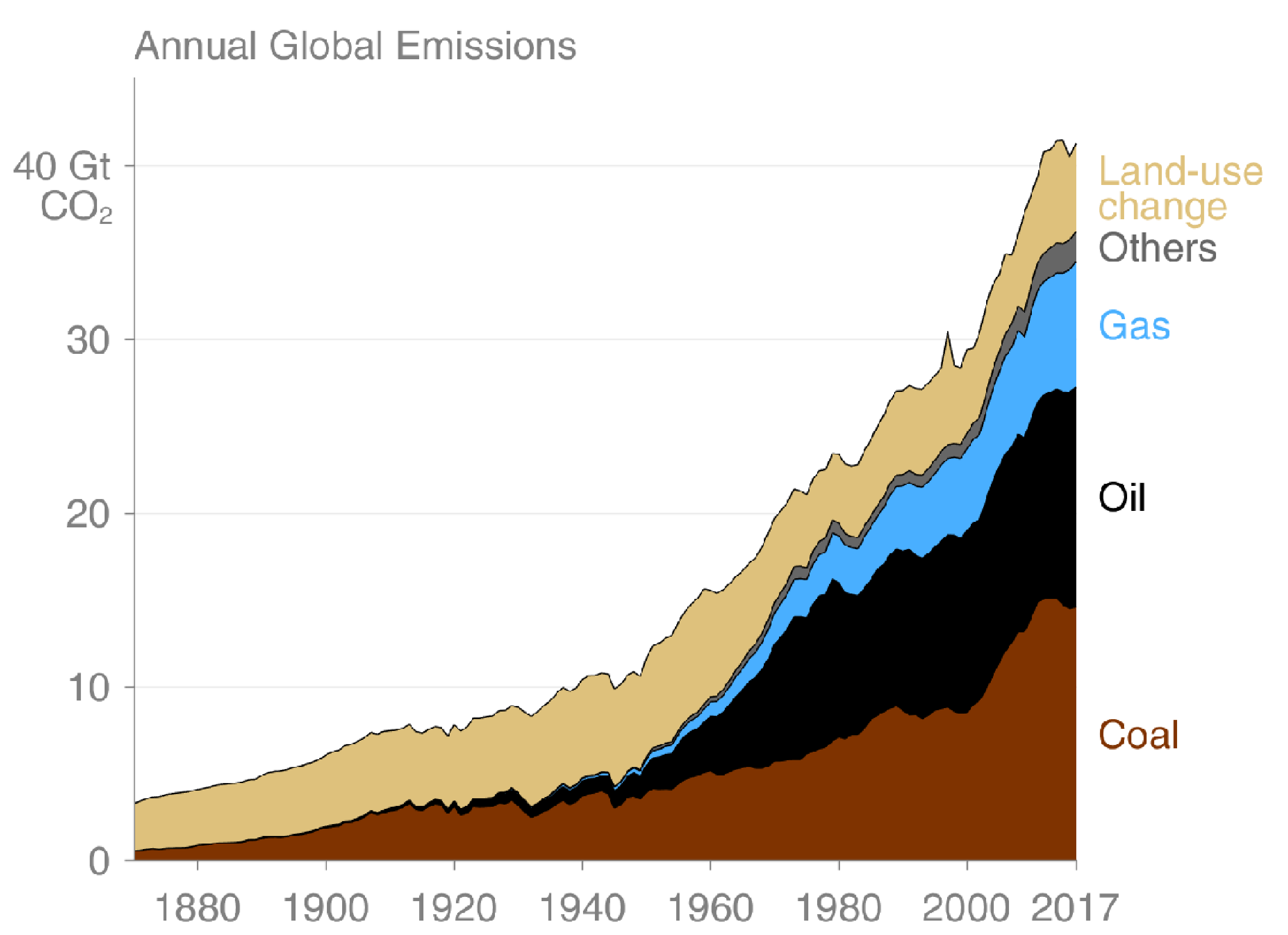
5,0 %

2018

19 %

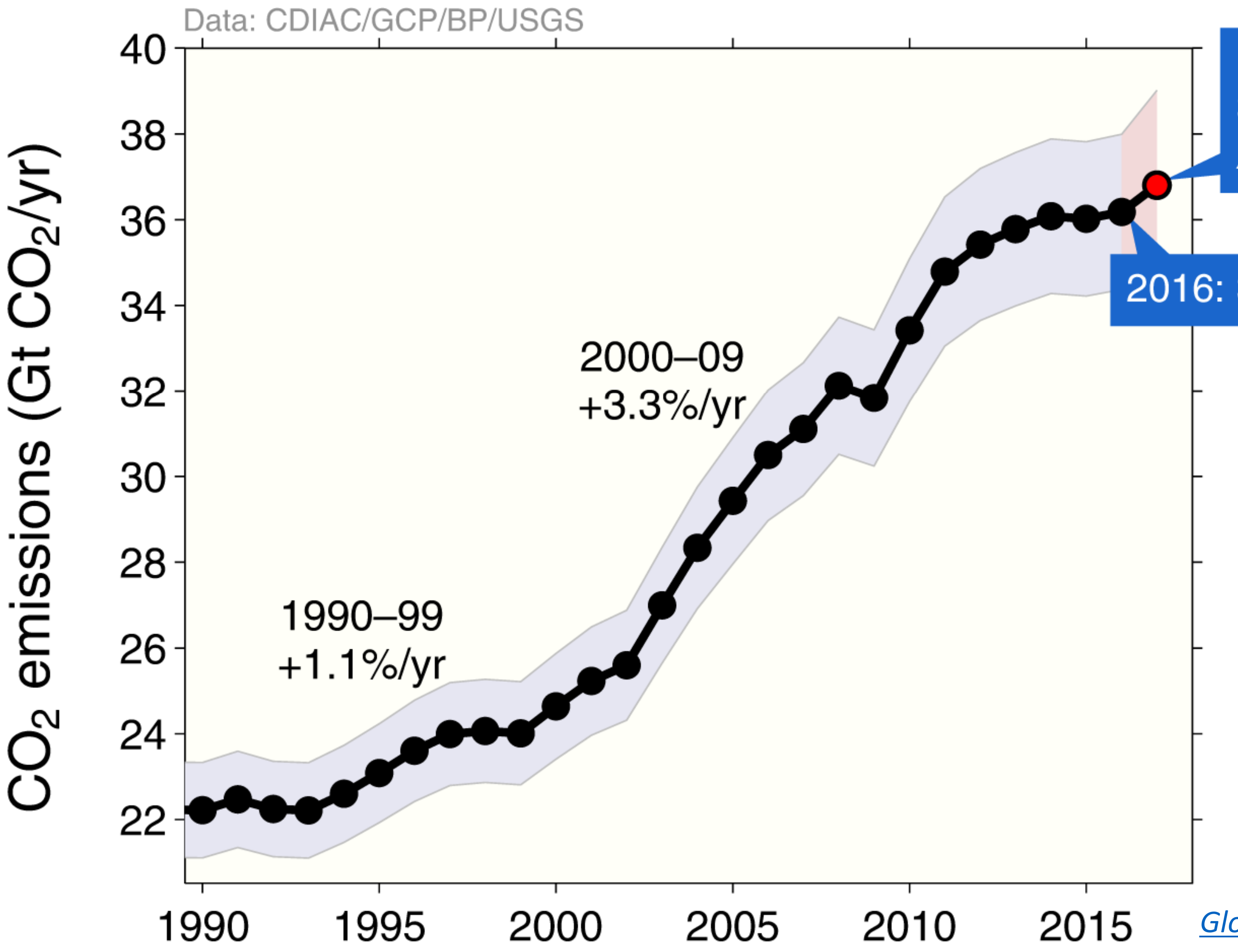
Souce: Prodes/INPE, MapBiomas

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



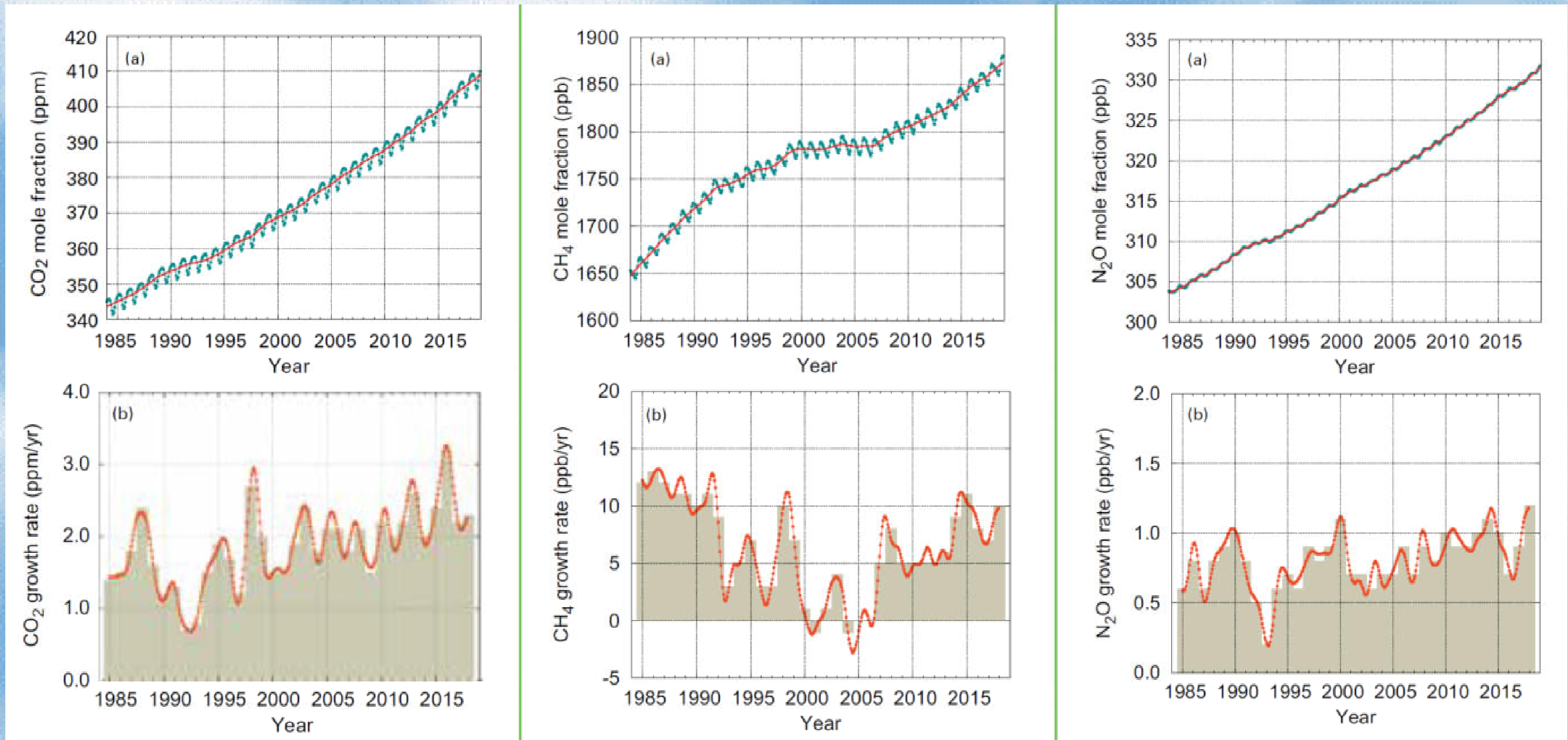
Source: Le Quéré et al 2018; Global Carbon Budget 2018

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

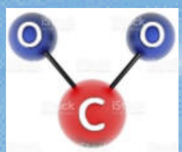


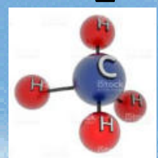
Global Carbon Budget 2017

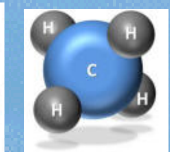
Concentrações de CO_2, CH_4 e N_2O

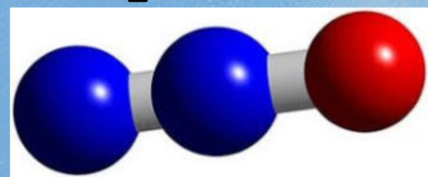


Aumentos desde 1750: CO_2: 147%, CH_4: 259%, N_2O: 123%

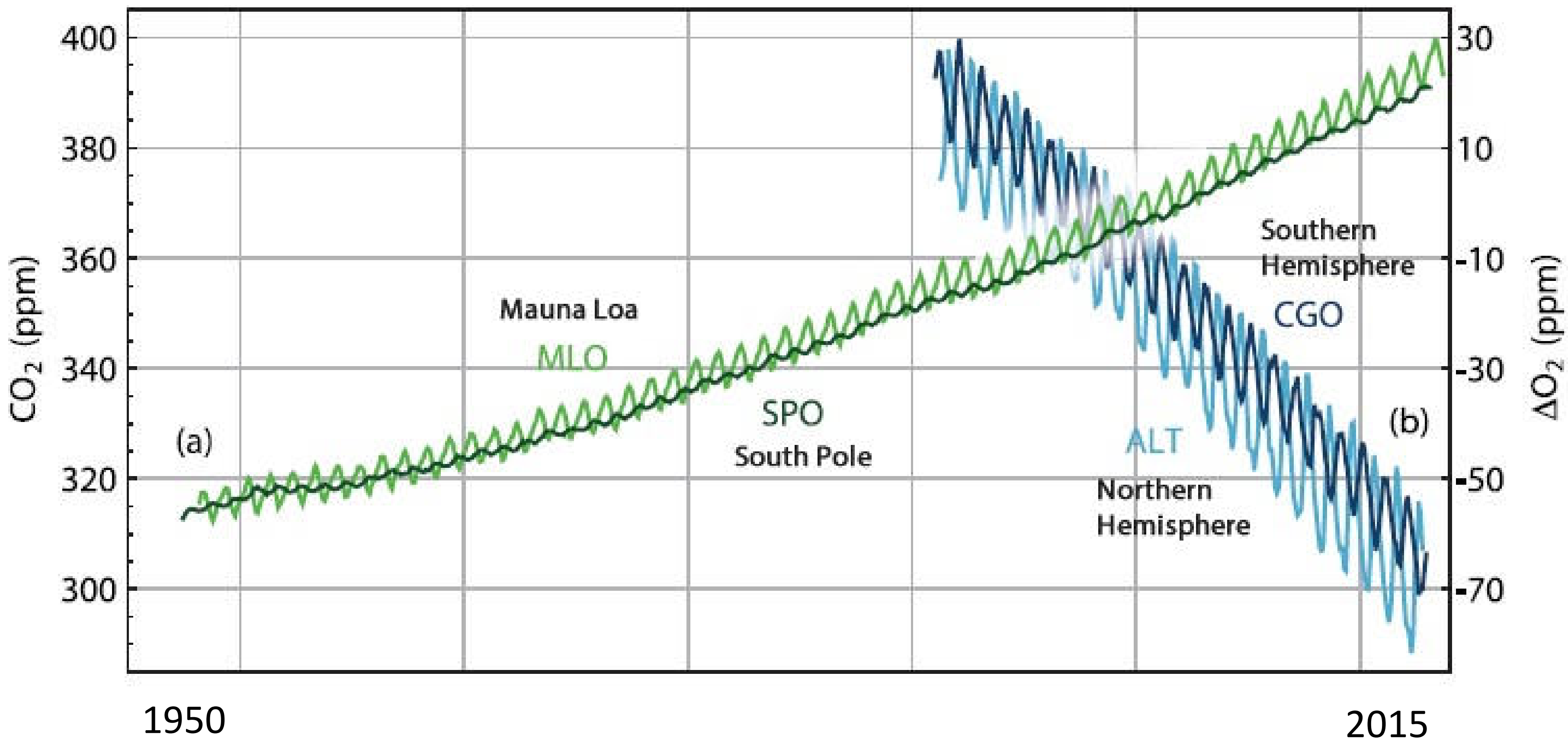








Aumento de CO_2 e diminuição de O_2



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%

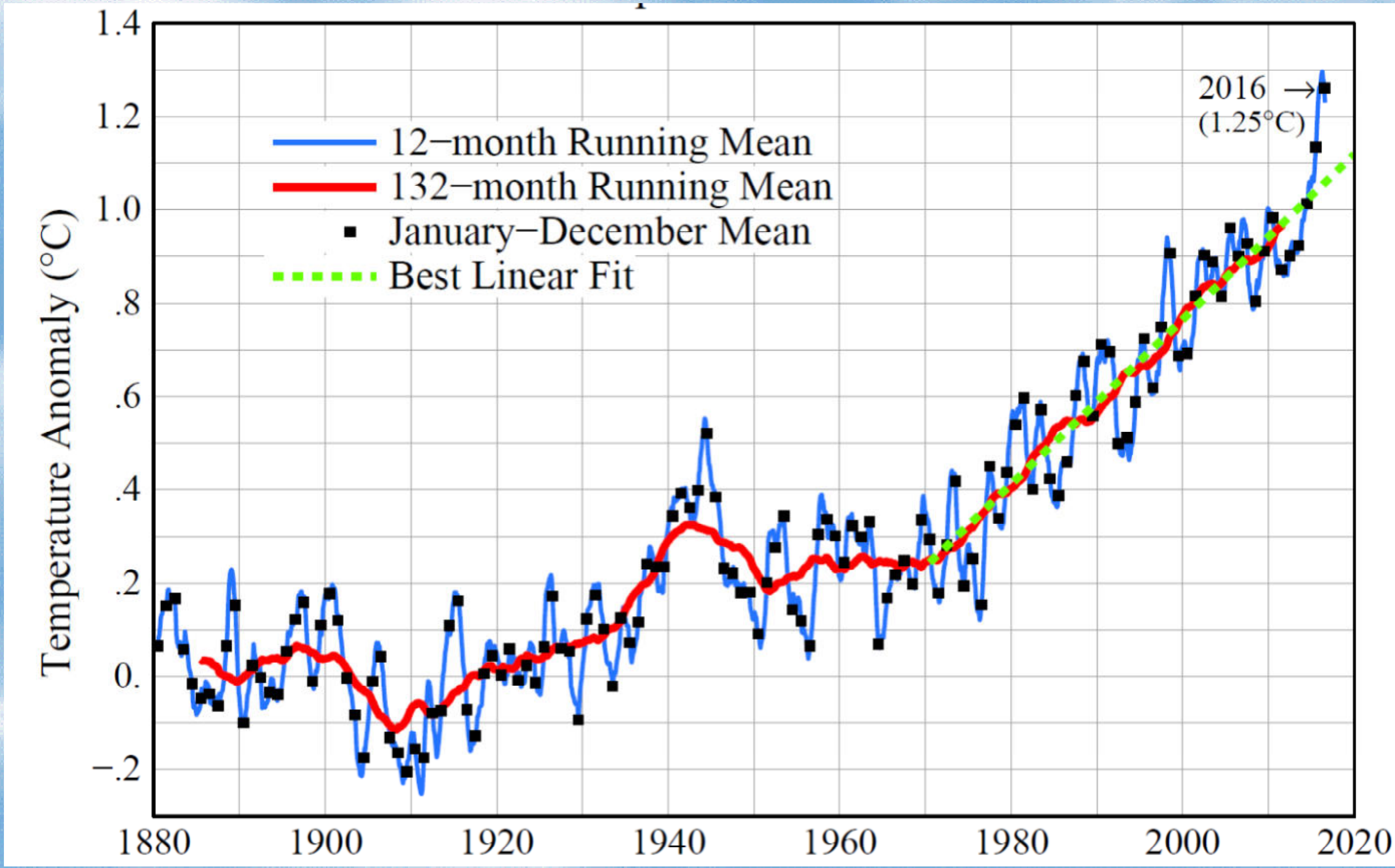
11.6 $GtCO_2$/yr

22%

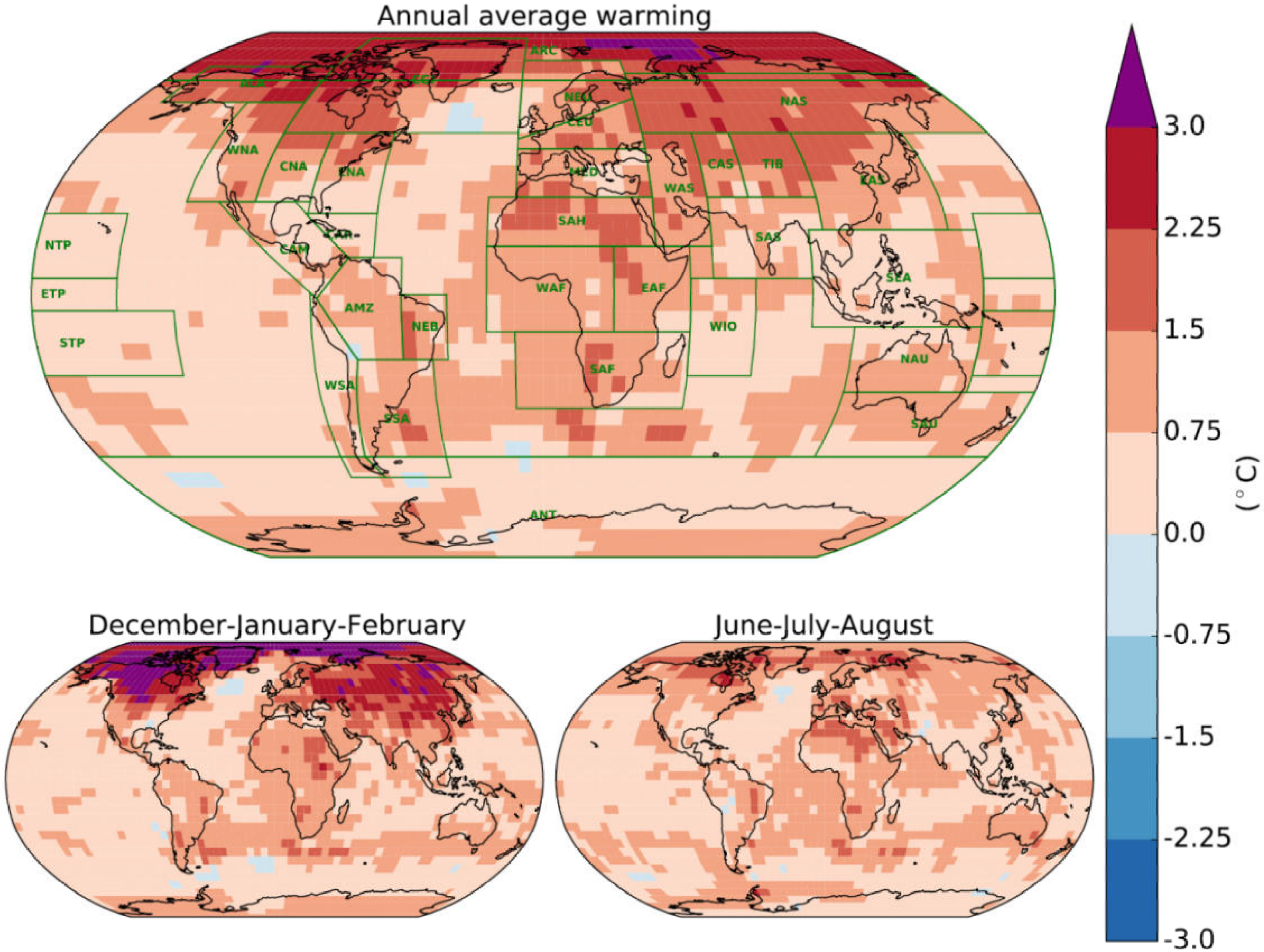
8.9 $GtCO_2$/yr

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

Temperatura média global 1880-2017

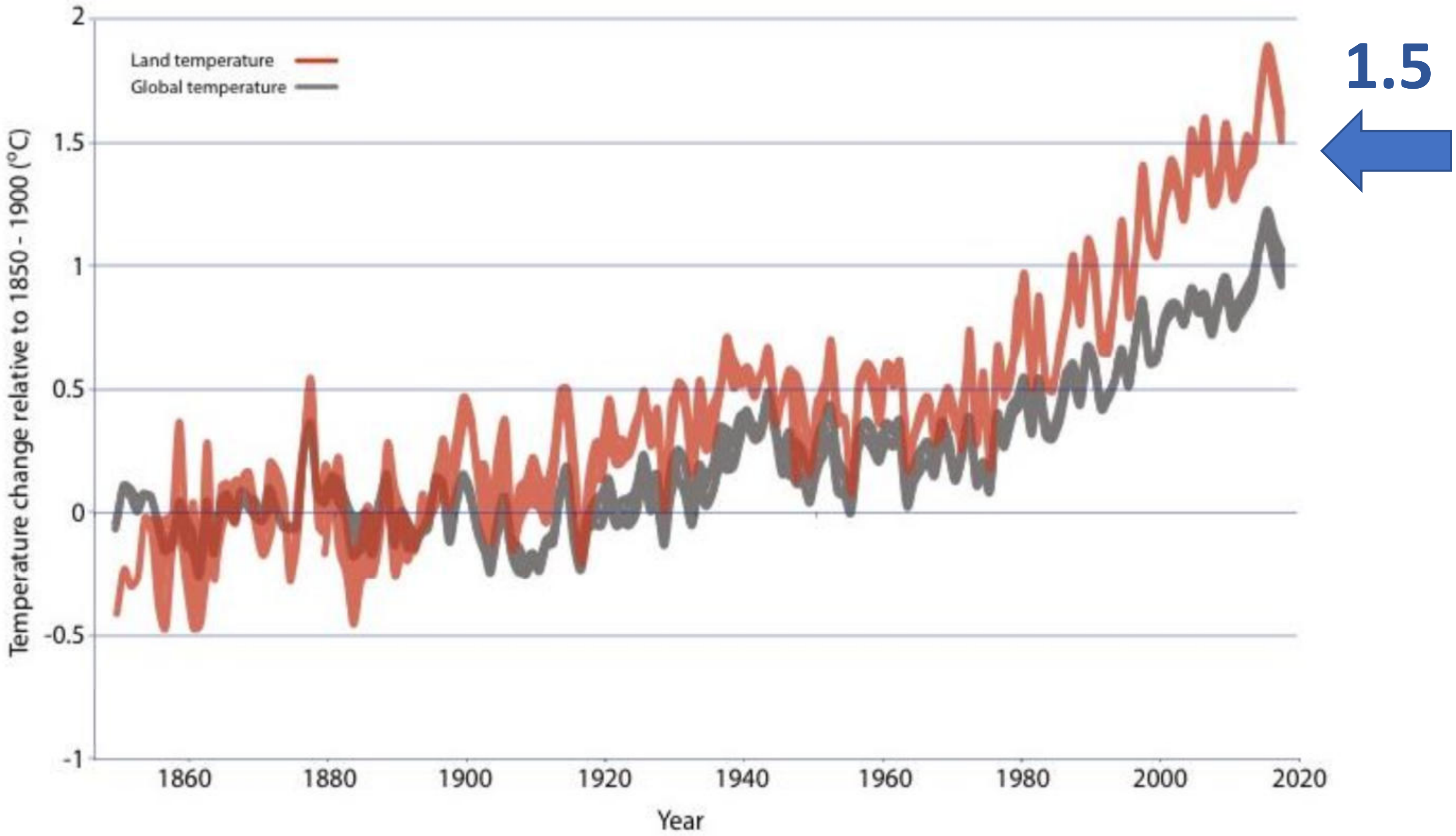


Aumento observado de temperatura de 1901 a 2012
Distribuição espacial não é homogenea



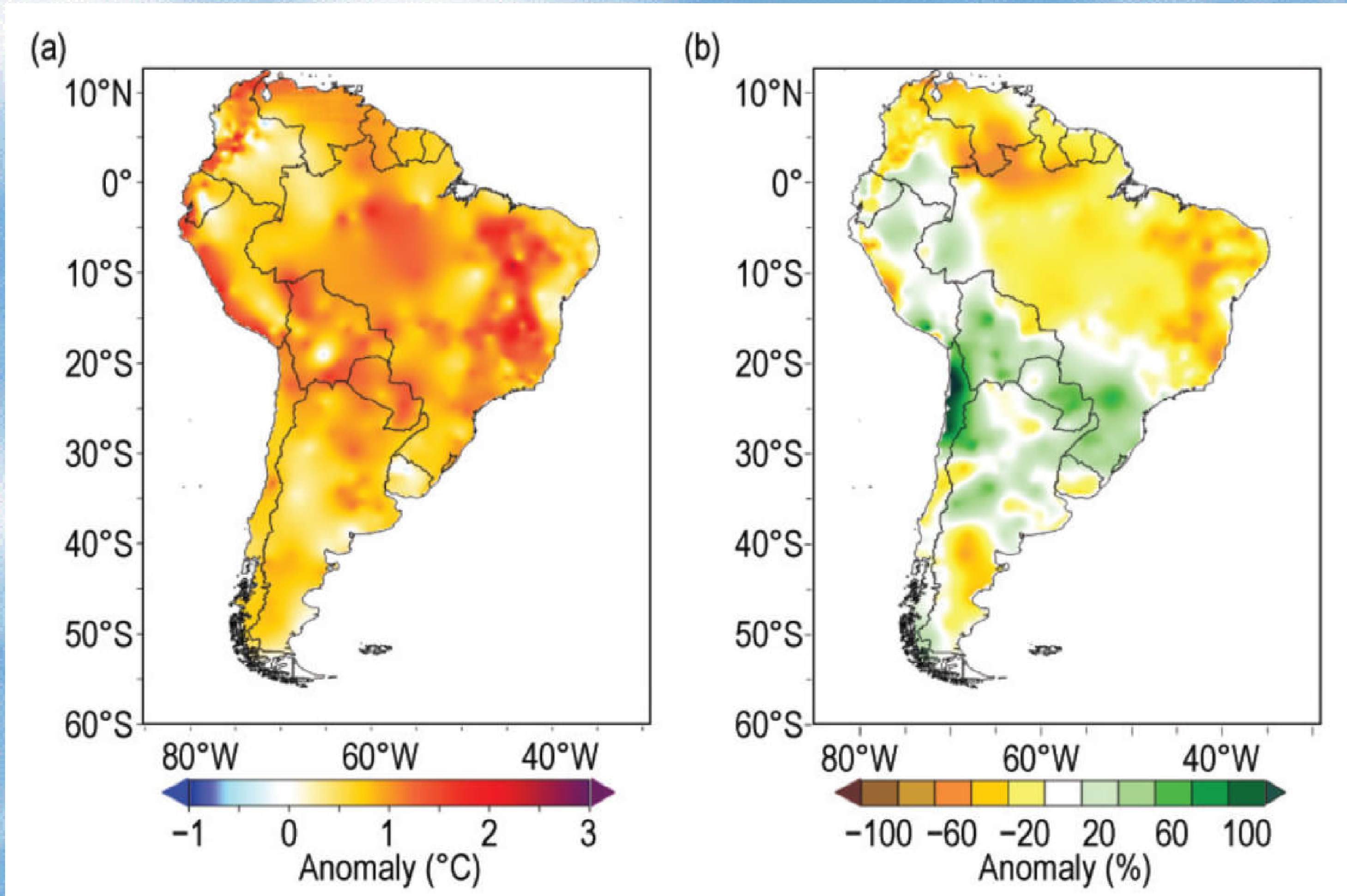
Source: IPCC 2018 Special Report on Global Warming of 1.5°C

Aumento da temperatura nos continentes e aumento global



IPCC SRCCL 2019

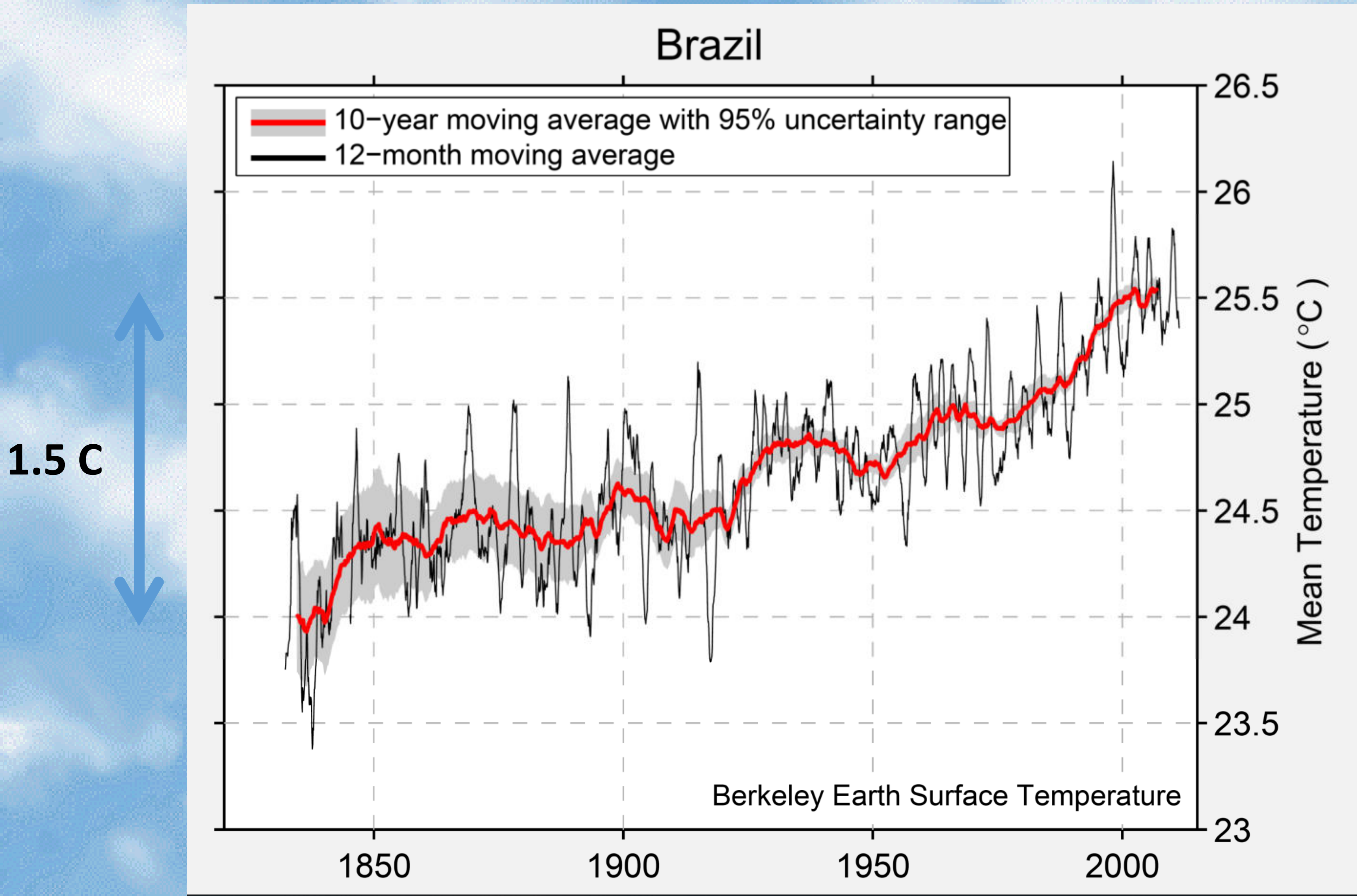
América do Sul: (a) anomalias de temperaturas (°C) e (b) anomalias de chuva (%)



Período de base: 1981–2010.

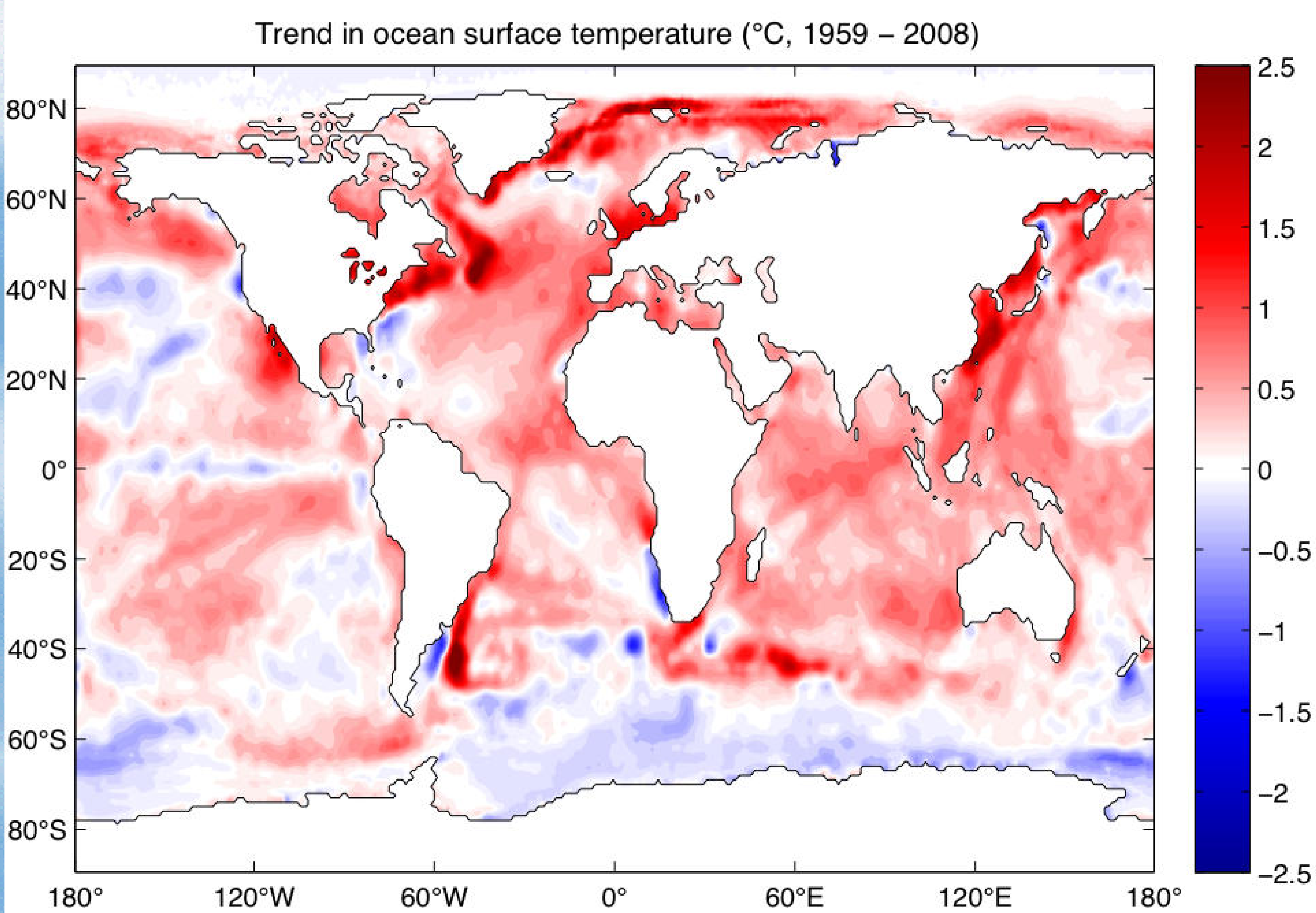
Fonte: State of the Climate in 2015, Bull. Amer. Meteor. Soc., 97 (8), 2016.

Aumento da temperatura média no Brasil

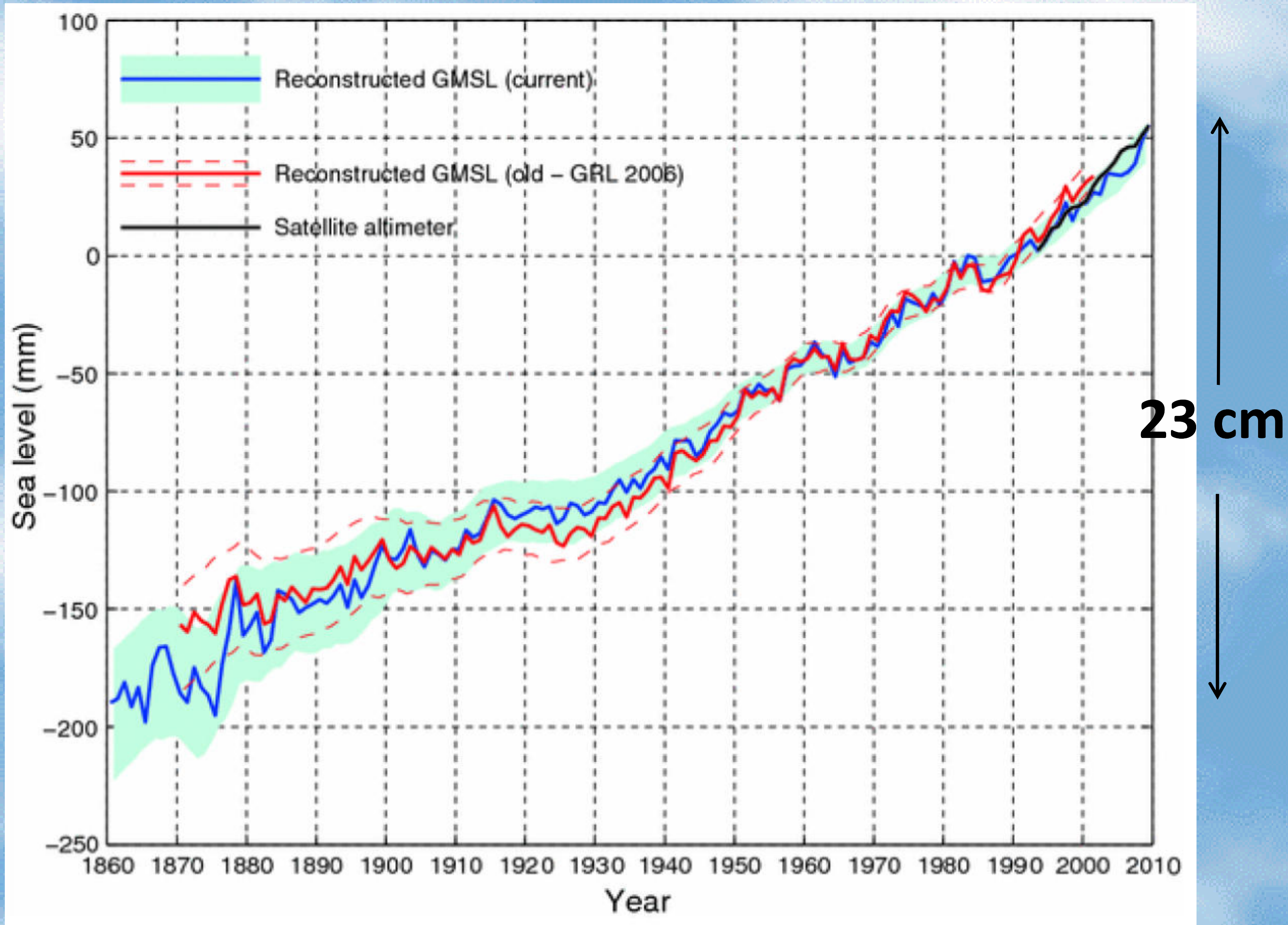


http://berkeleyearth.org/

Temperatura do oceano, também aumentando - 1959 - 2008

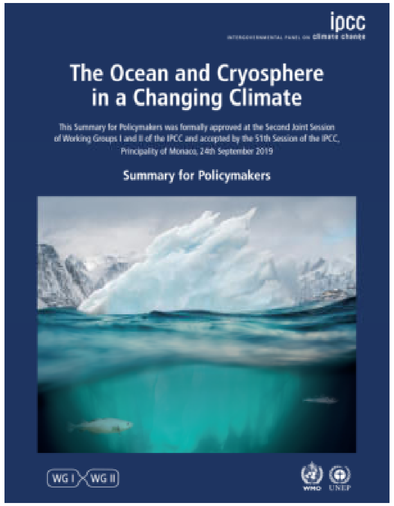


Nível médio dos oceanos subindo - 1860 a 2010

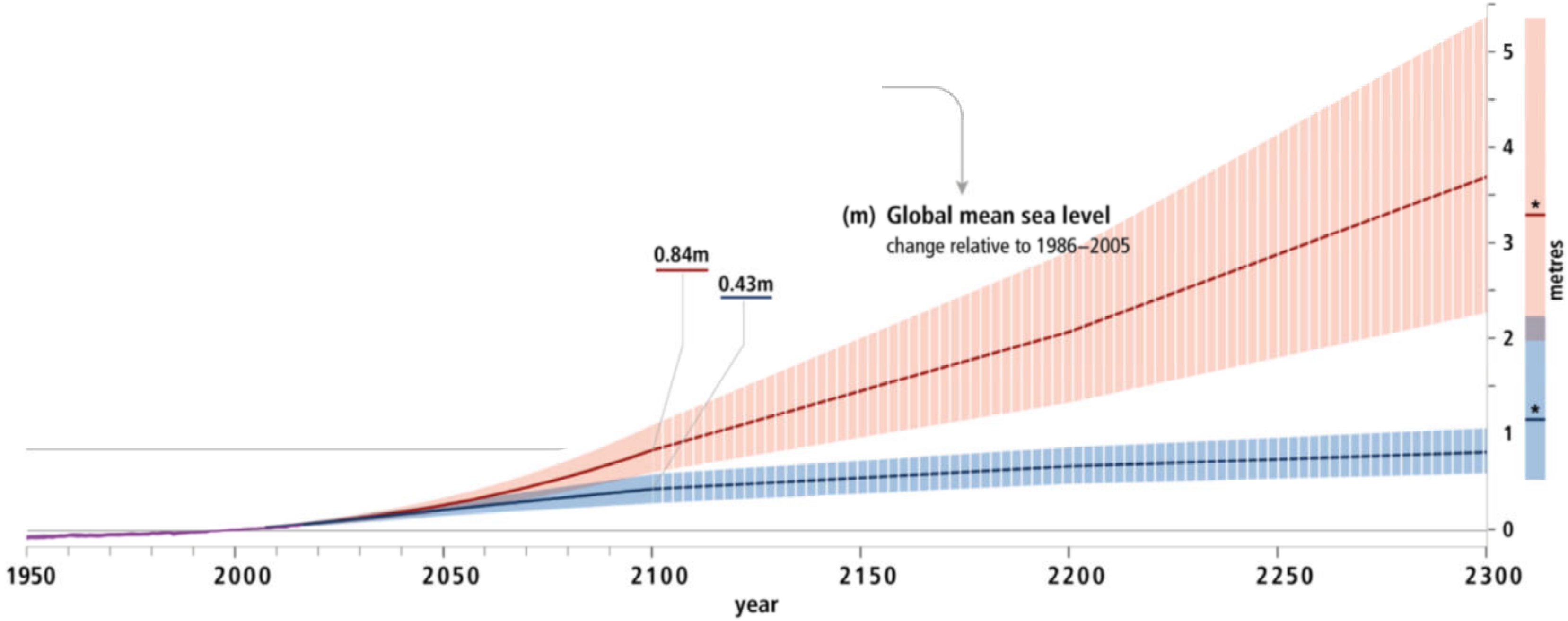


Global mean sea level (GMSL) reconstructed from tide gauge data (blue, red) and measured from satellite altimetry (black).

Source: Church and White (2011).



Aumento do nível do mar em 1950 – 2100 - 2300

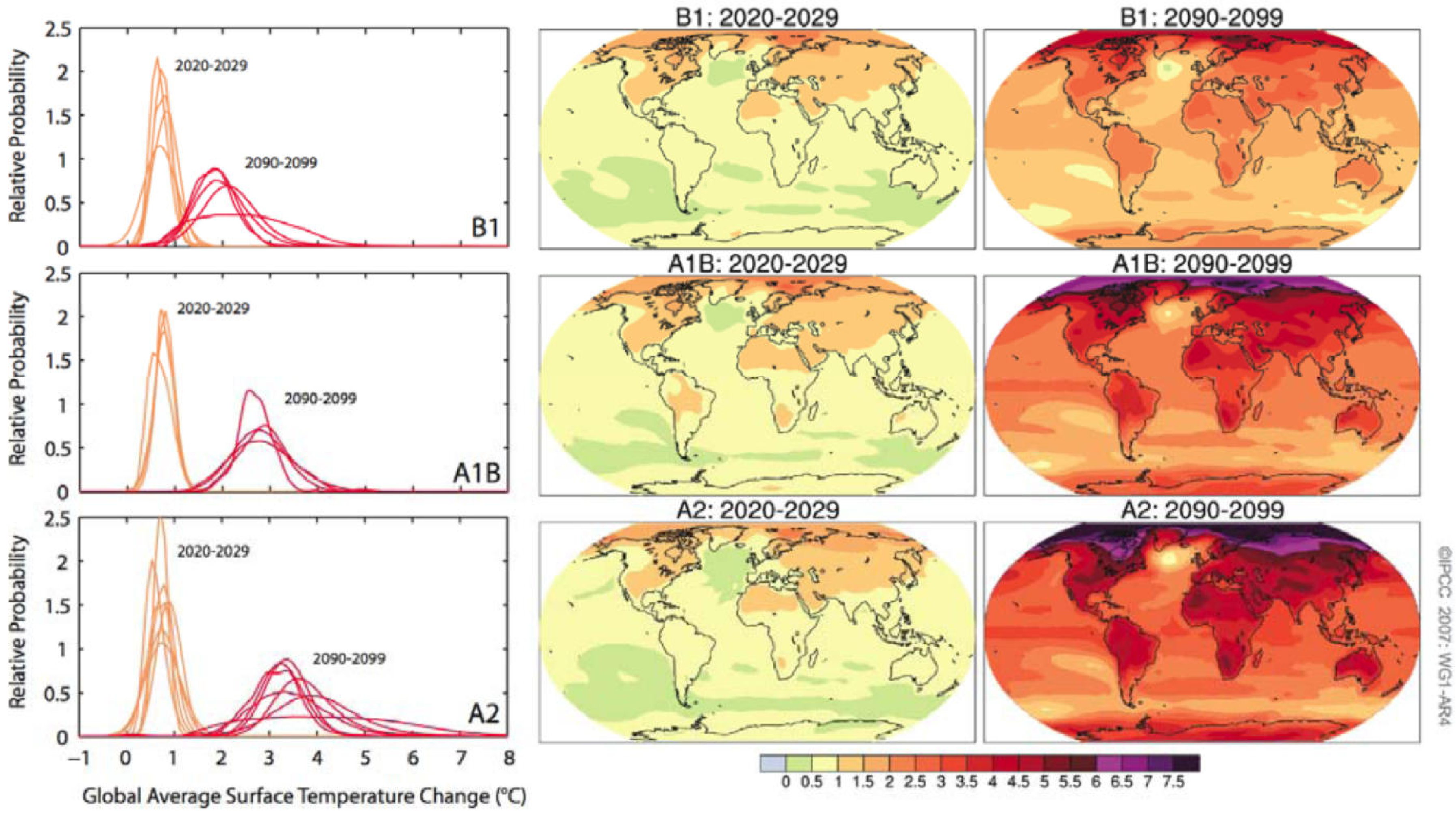


IPCC SRCC 2019


O futuro da América do Sul?
Georgetown
Paramaribo
Lima
Asunción
Rio de Janeiro
Buenos Aires
Montevideo
National Geographic + USGS topography

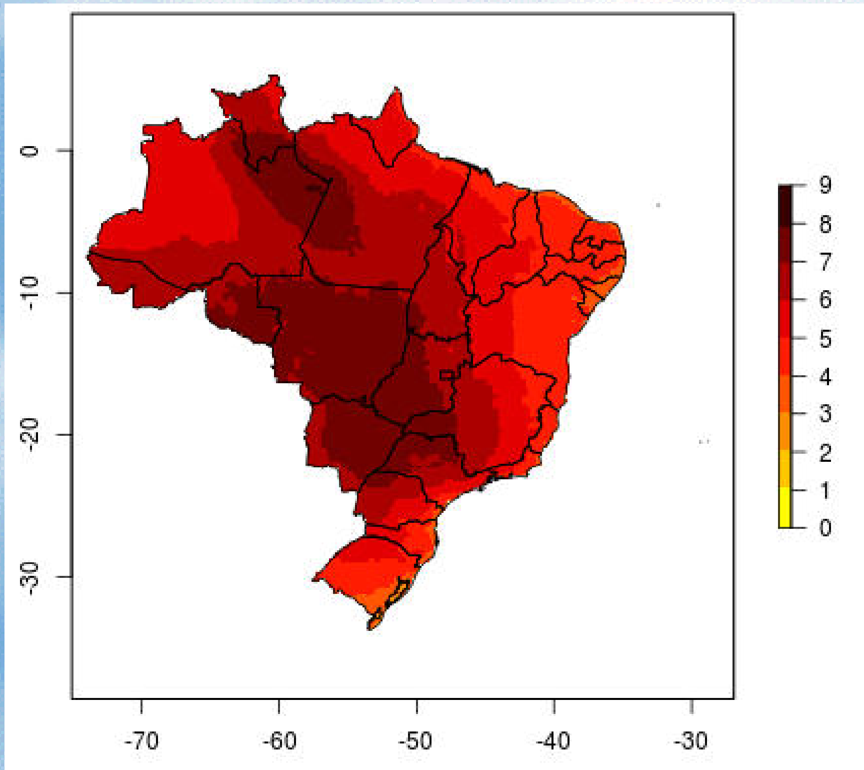

NO ANTROPOCENO
OS OCEANOS ESTÃO SOFRENDO TRANSFORMAÇÕES INÉDITAS EM ATÉ 300 MILHÕES DE ANOS
1°C MAIS QUENTES
26% MAIS ÁCIDOS
2% A MENOS DE OXIGÊNIO DISSOLVIDO

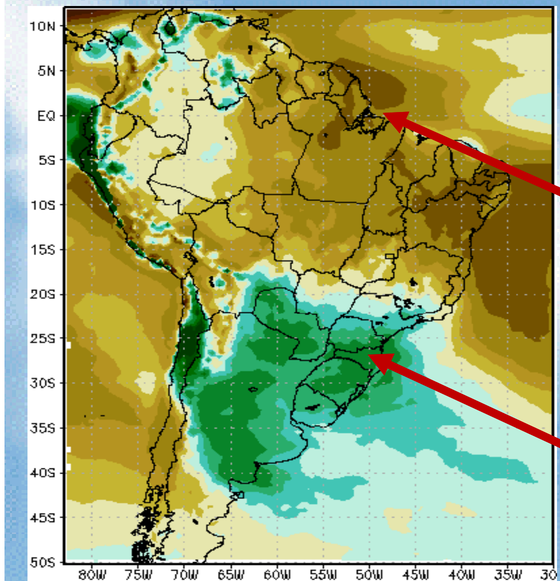
Estimates of temperature increase for 2029 and 2099 following 3 emissions scenarios



Aumento médio de temperatura esperado para o Brasil 2071-2099

Mudança na precipitação esperada para o Brasil 2071-2100





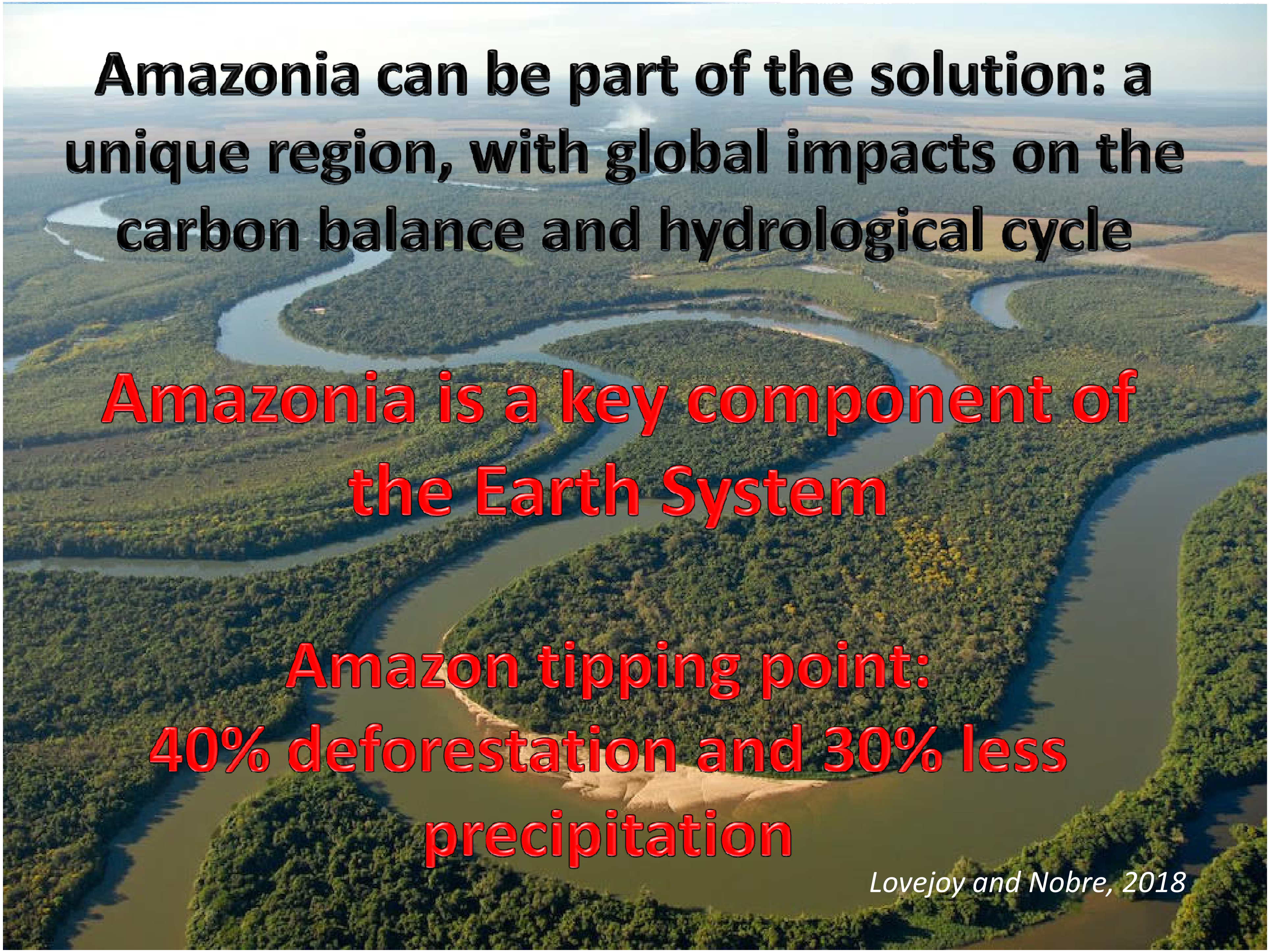
Mudanças na chuva (%) em 2071-2100 relativo a 1961-90.

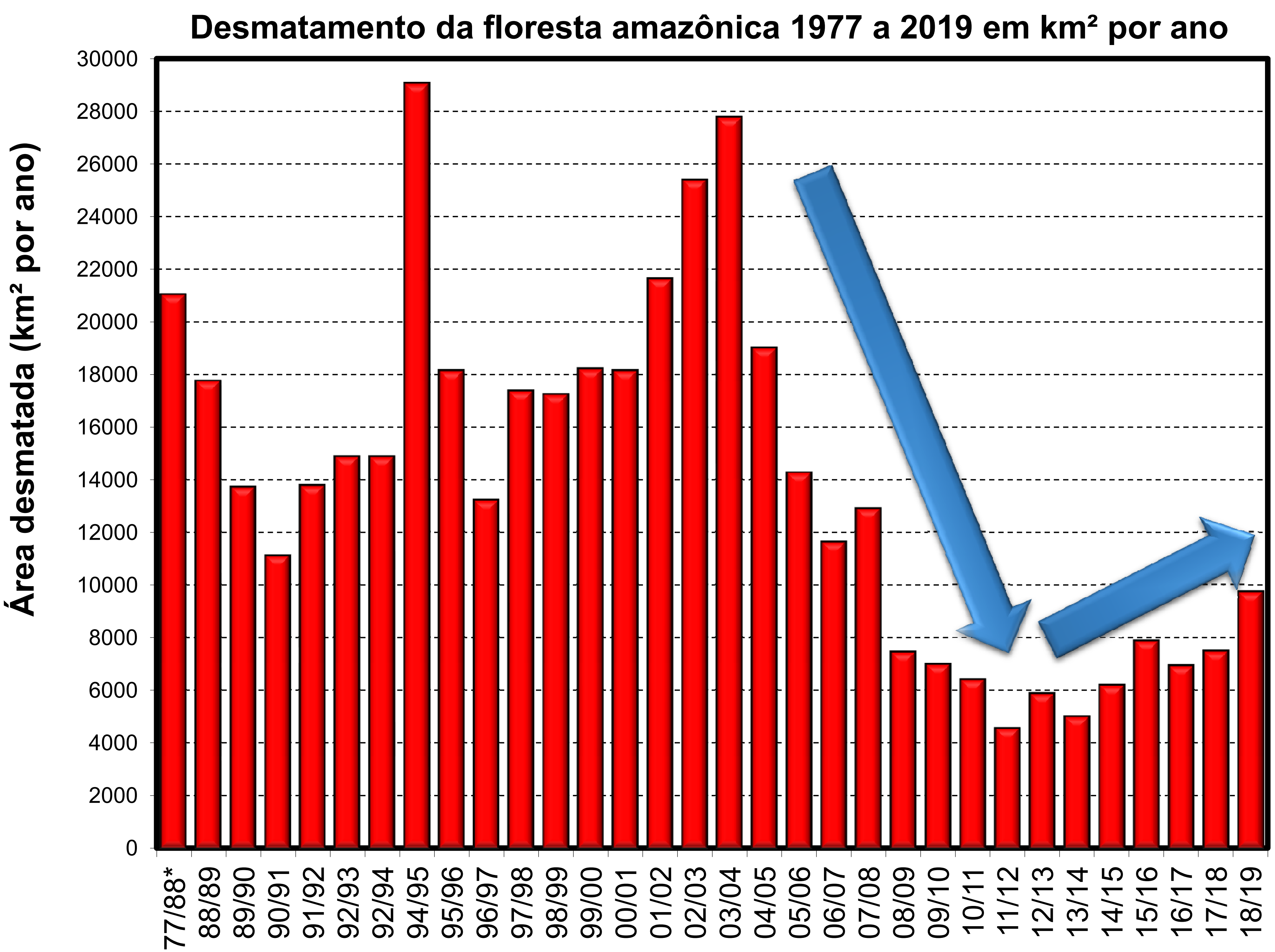
Amazonia e Nordeste do Brasil → deficiência de chuvas

Sudeste da America do Sul → aumento nas chuvas

Áreas continentais se aquecem mais que áreas oceânicas

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
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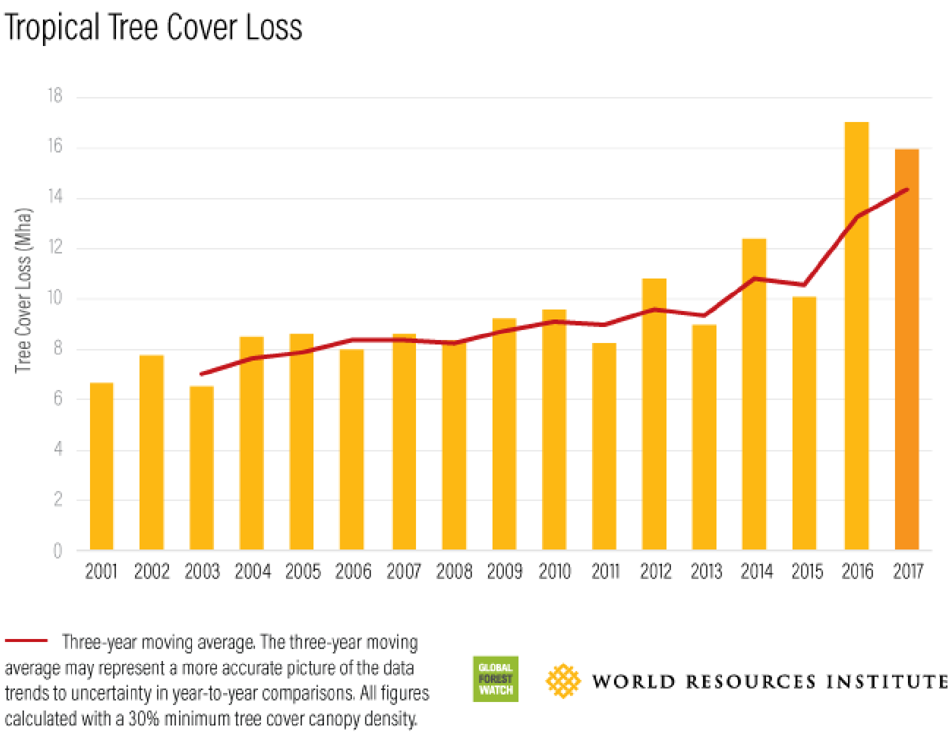
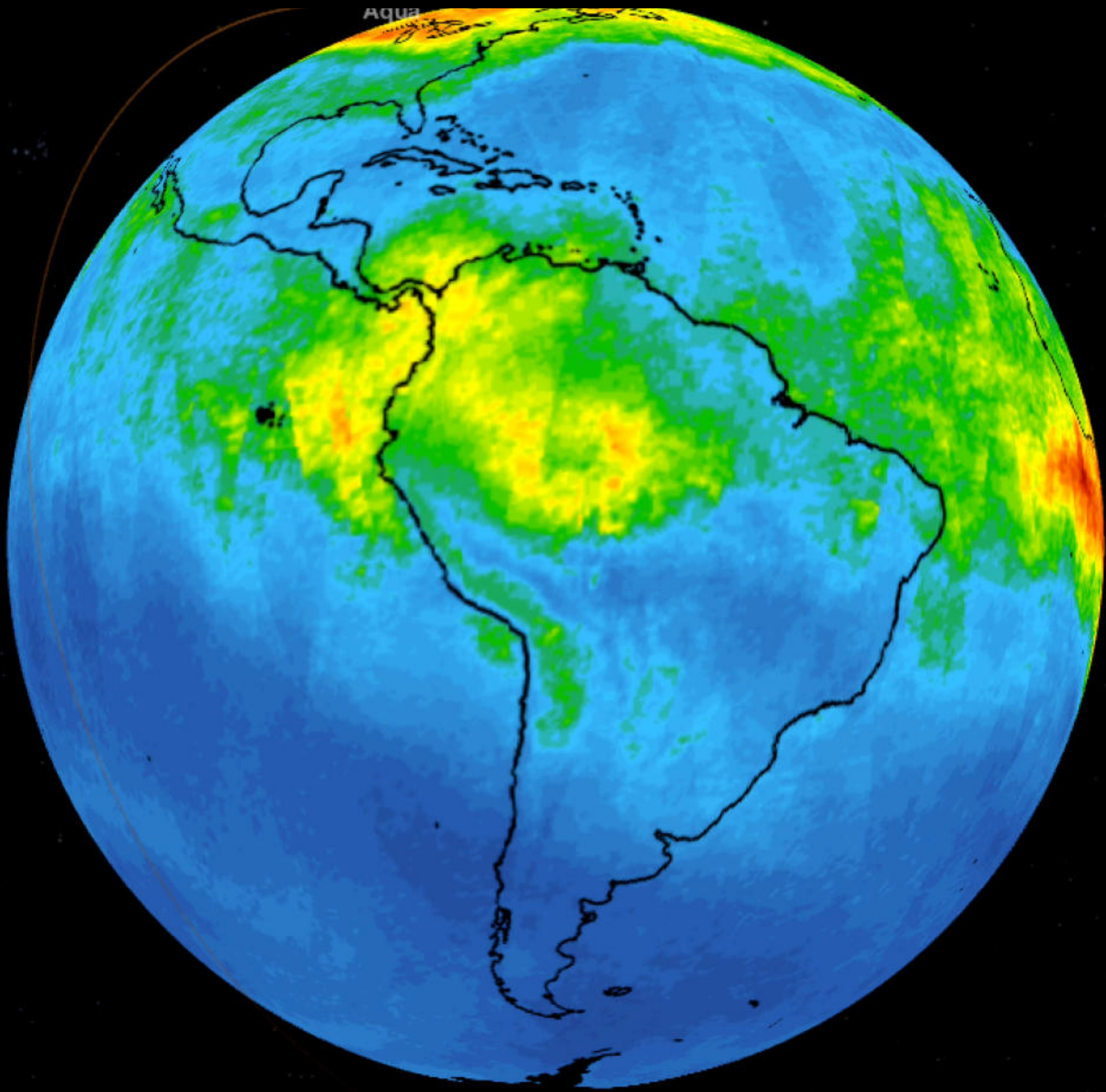
17/18
18/19

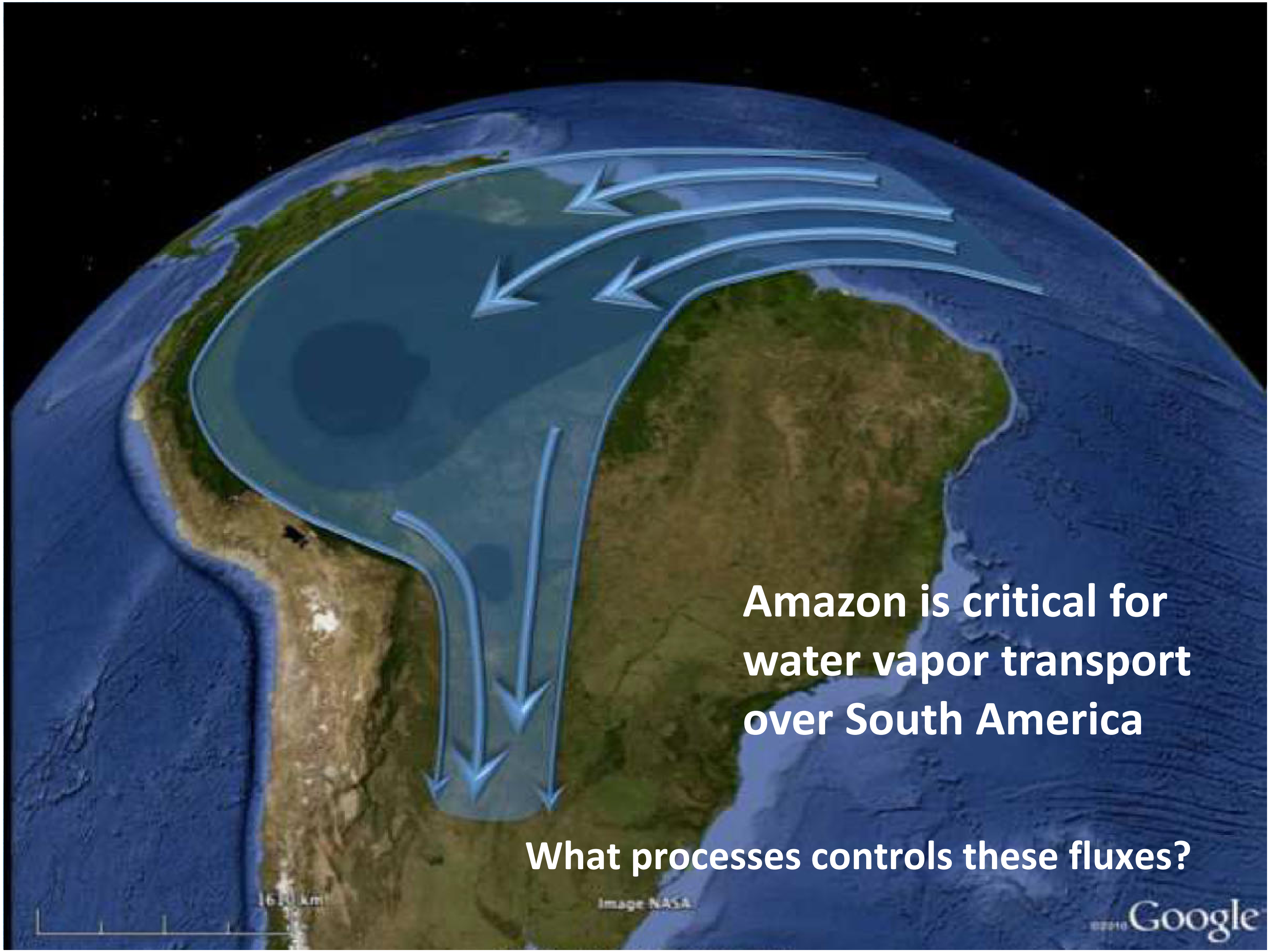
Desflorestamento tropical no planeta



Os 10 países que mais desmataram em 2017

AIRS Carbon monoxide at 18000 ft



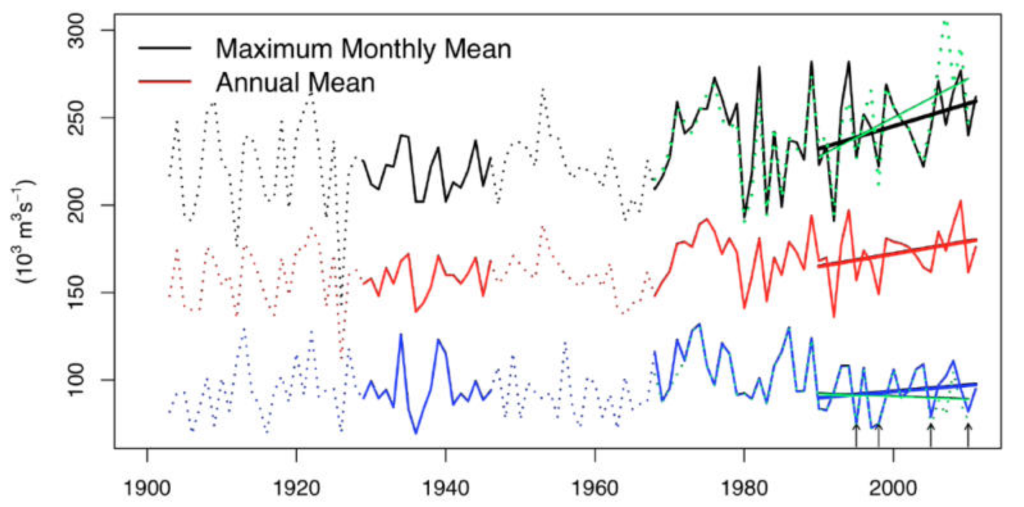

Amazon is critical for
water vapor transport
over South America
What processes controls these fluxes?
1610 km
Image NASA
Google

O ciclo hidrológico da Amazônia está se intensificando?

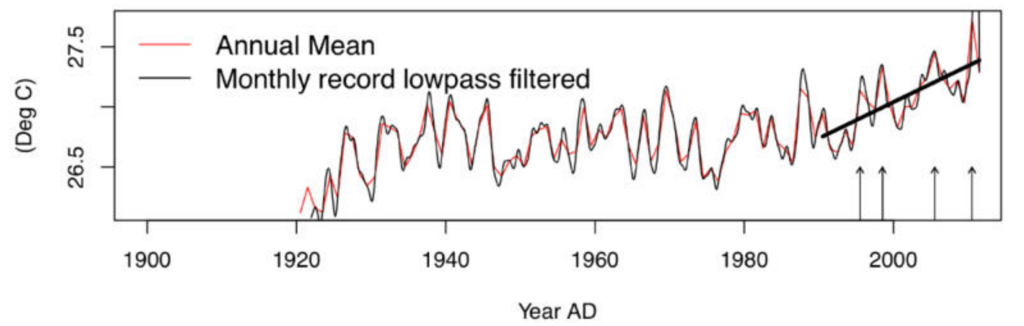
Descarga do Rio Amazonas em Óbidos, no Pará, mostrando o fluxos máximos, mínimos e médios.

Temperatura superficial no Oceano Atlântico Tropical

Descarga do Rio Amazonas em Óbidos, Pará

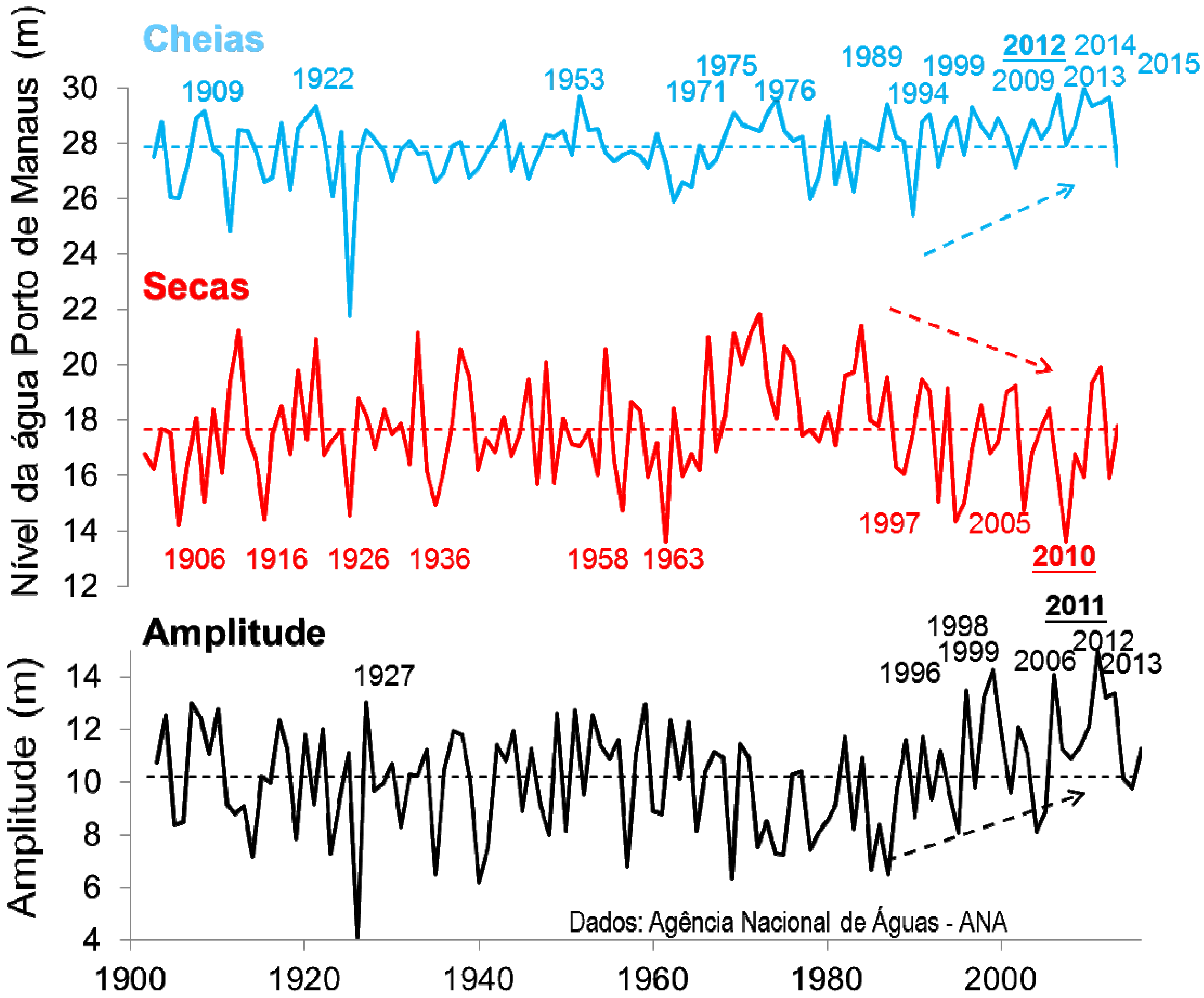


Temperatura do Oceano Atlantico Tropical



Gloor et al. 2013

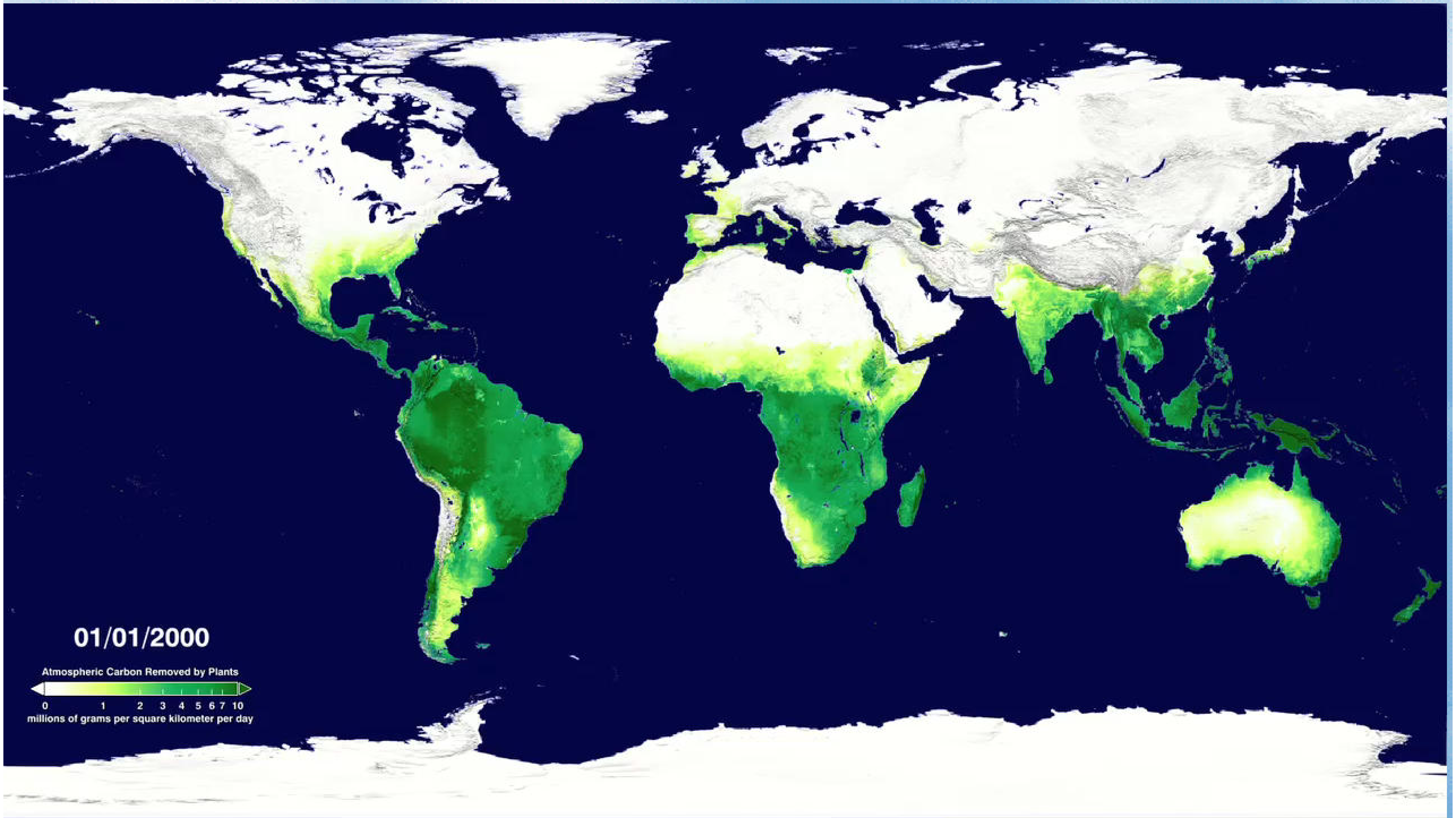
Níveis do Rio Amazonas no porto de Manaus 1900-2015



Jochen Schöngart, 2017

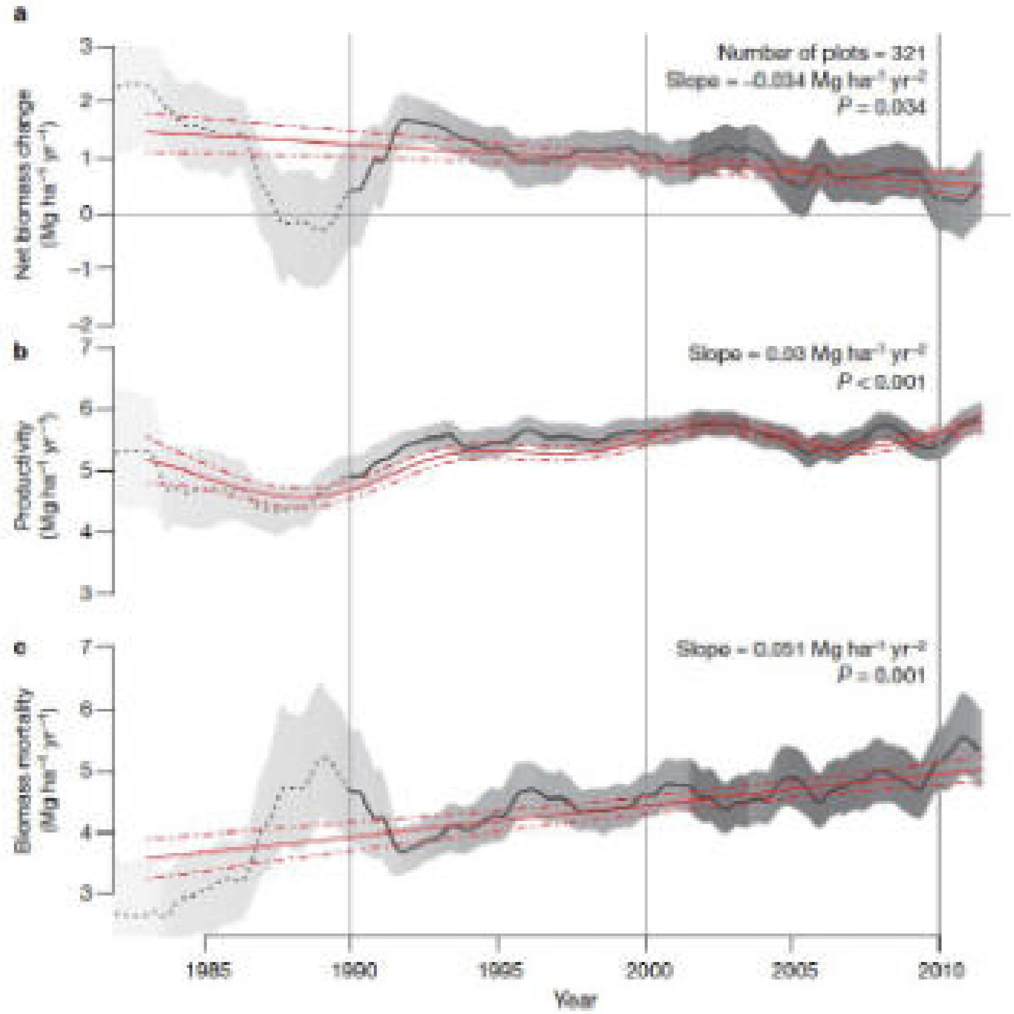
Quanto de carbono as plantas retiram da atmosfera?

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



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

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

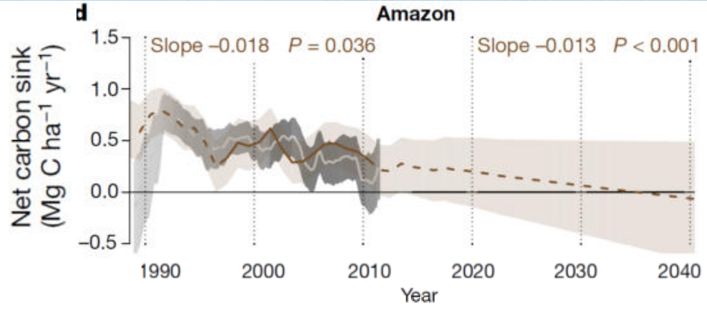
March 5, 2020

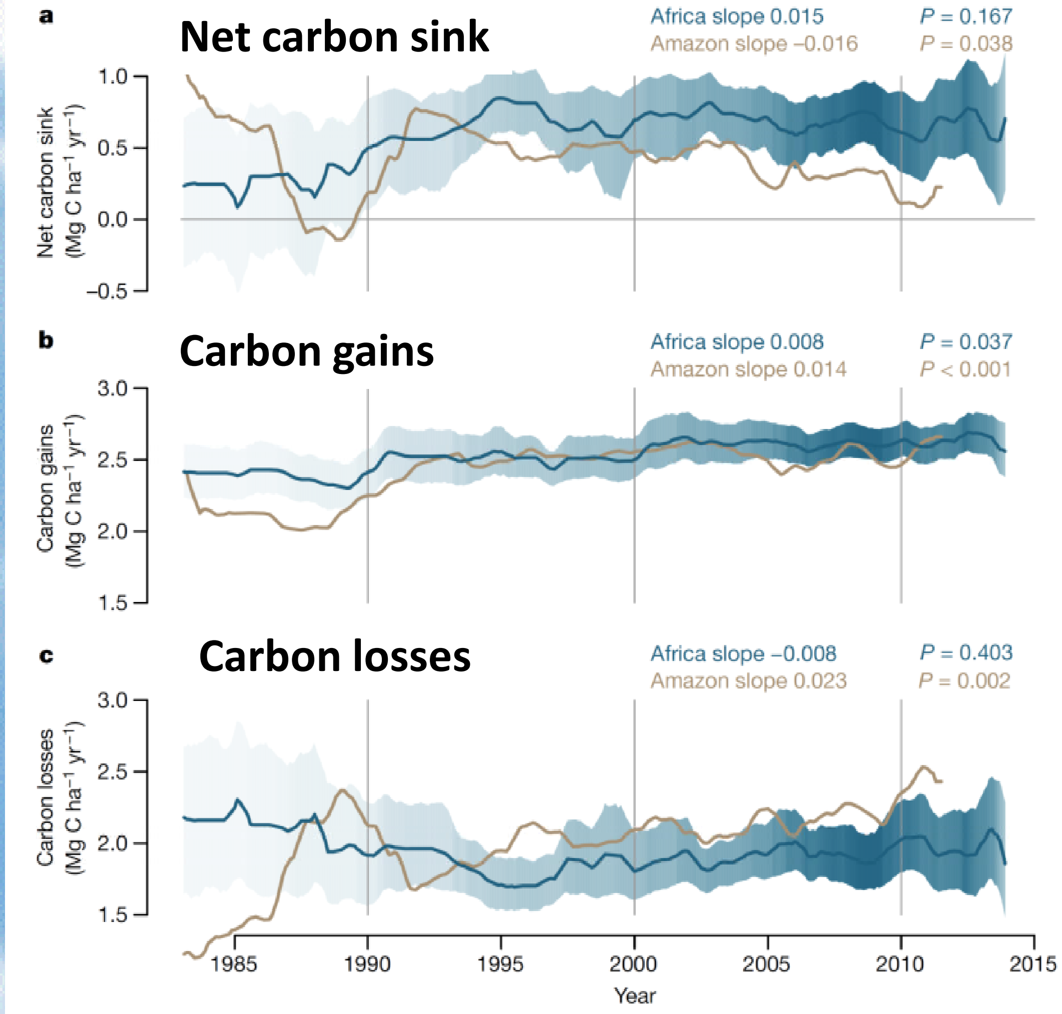
Article

Asynchronous carbon sink saturation in African and Amazonian tropical forests

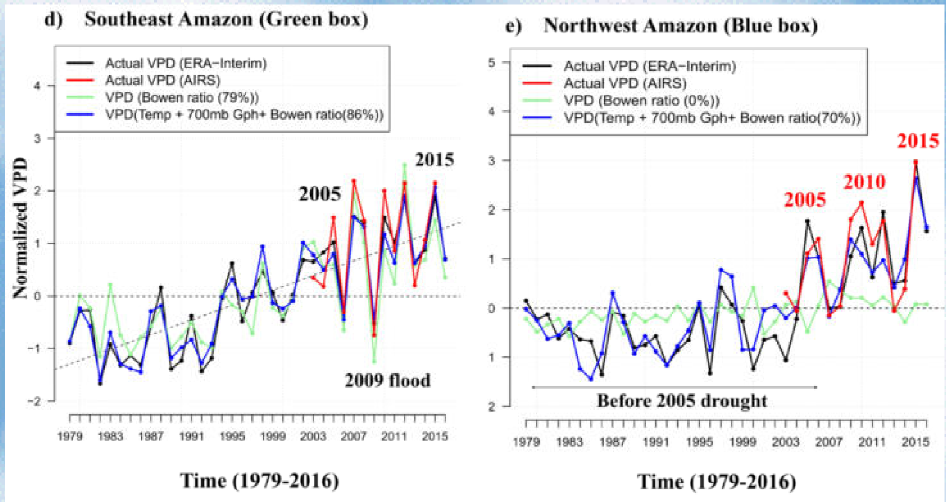
Long-term carbon dynamics of structurally intact oldgrowth tropical forests in Africa and Amazonia.

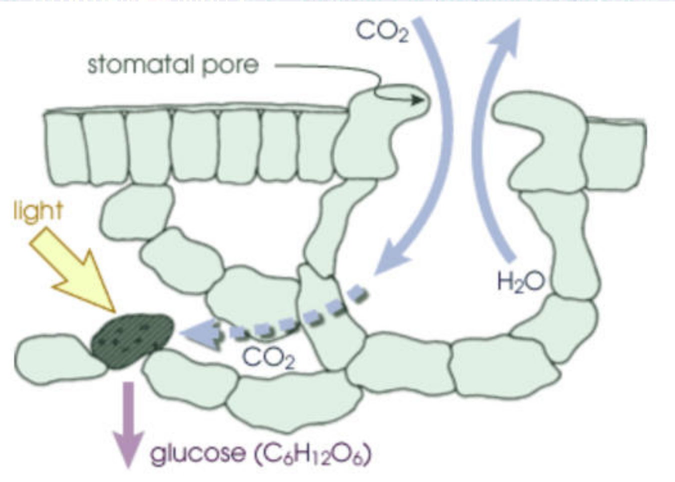
Net Carbon sink 1990-2040

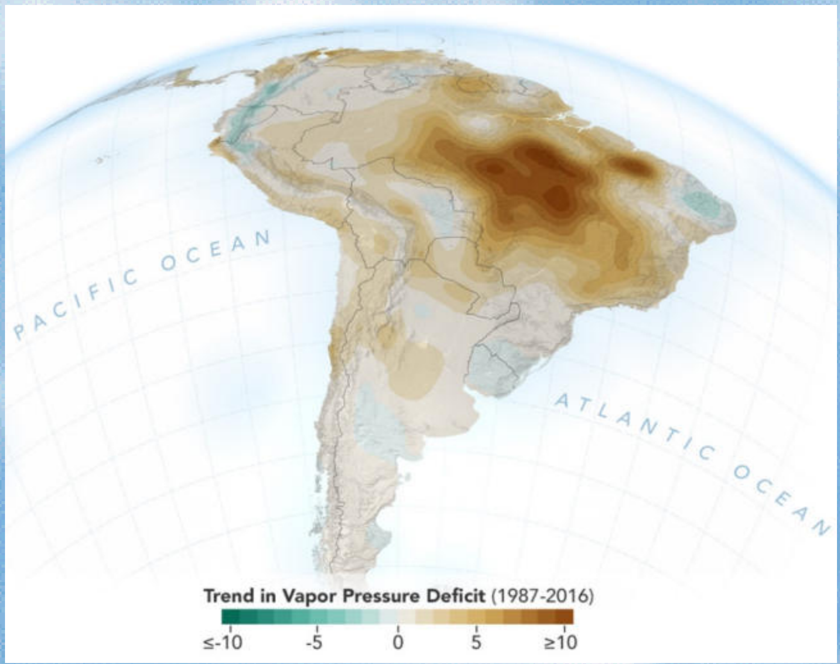




Increase in the Vapor Pressure Deficit: Decrease in evapotranspiration in Amazonia





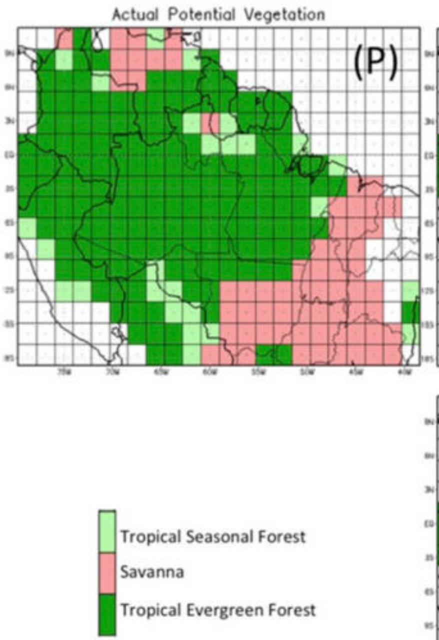


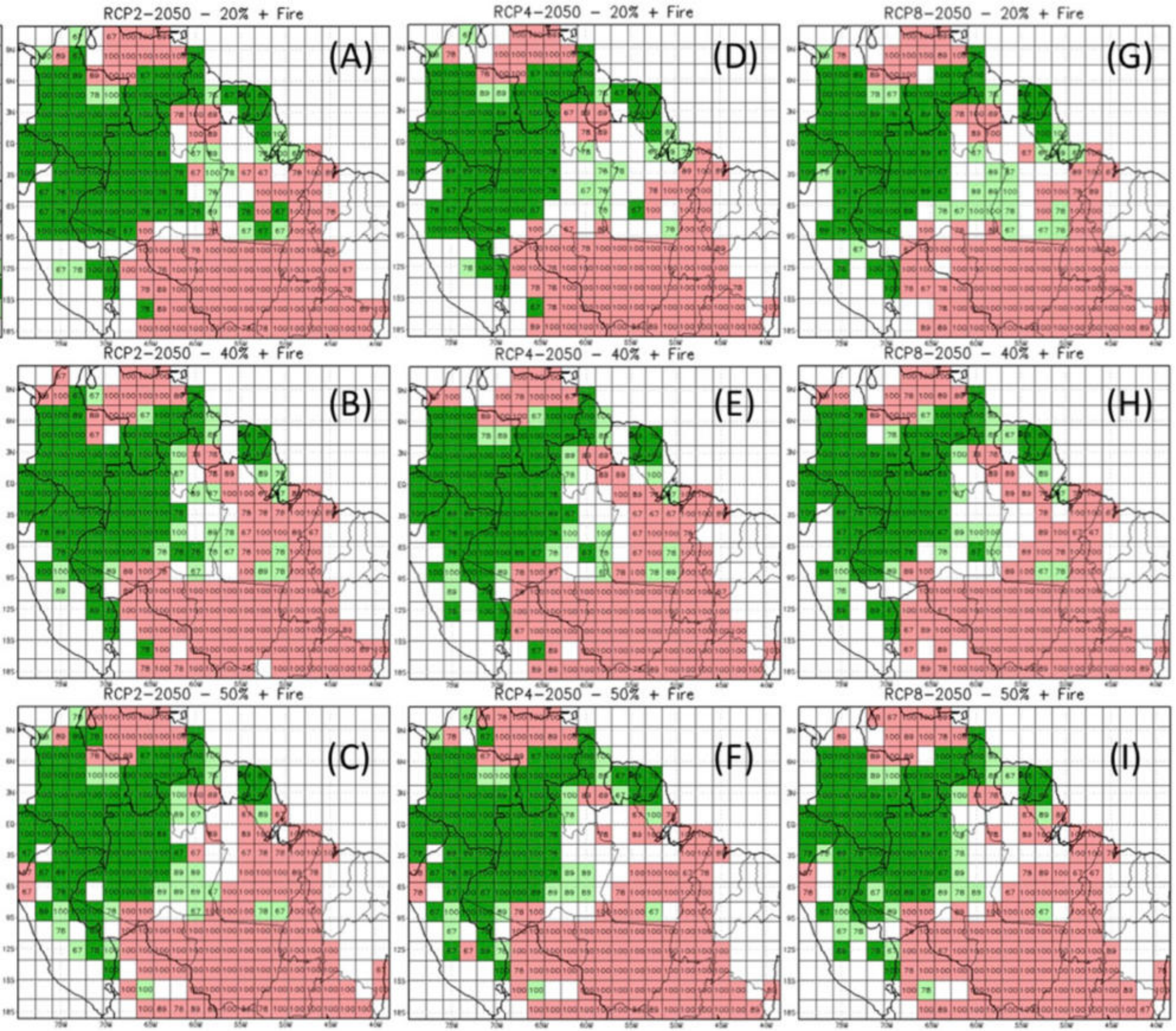
O déficit da pressão de vapor ou VPD é a diferença entre a quantidade de umidade no ar e quanta umidade o ar pode conter quando está saturado

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

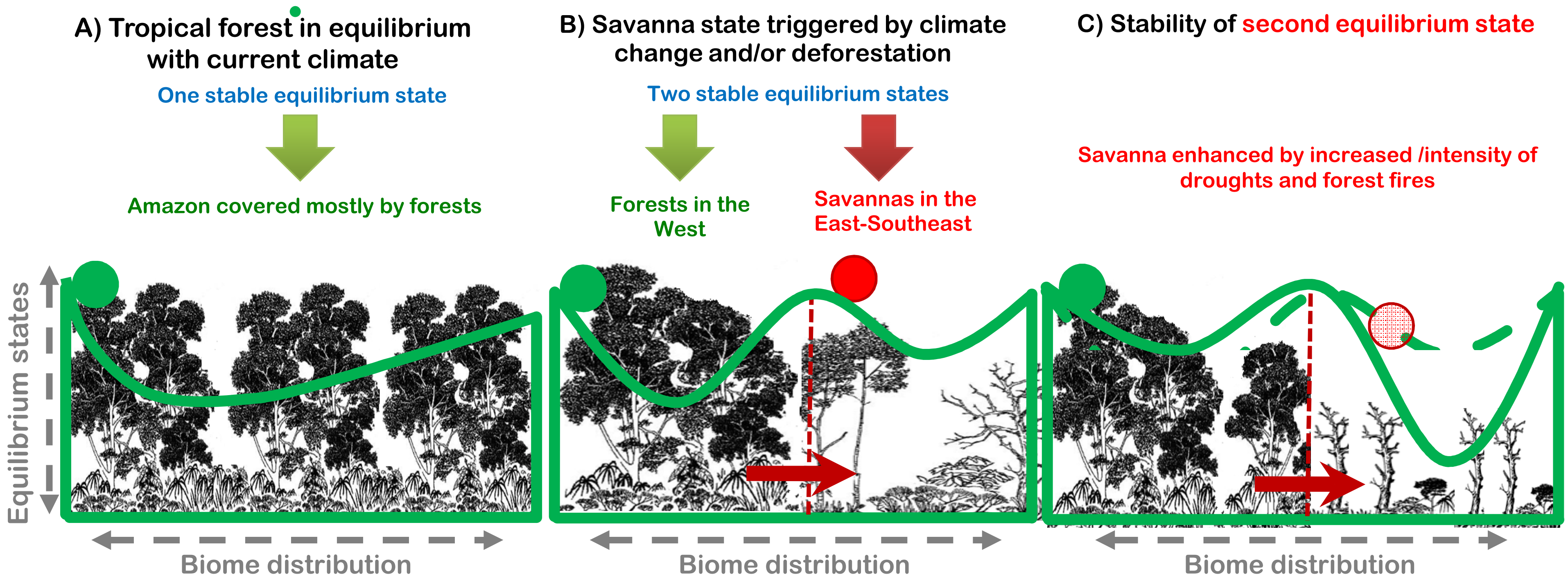




We believe that the sensible course is not only to strictly curb further deforestation, but also to build back a margin of safety against the Amazon tipping point, by reducing the deforested area to less than 20%, for the commonsense reason that there is no point in discovering the precise tipping point 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 ≈ 4ºC Amazon warming or
≈ 40% of total deforested area

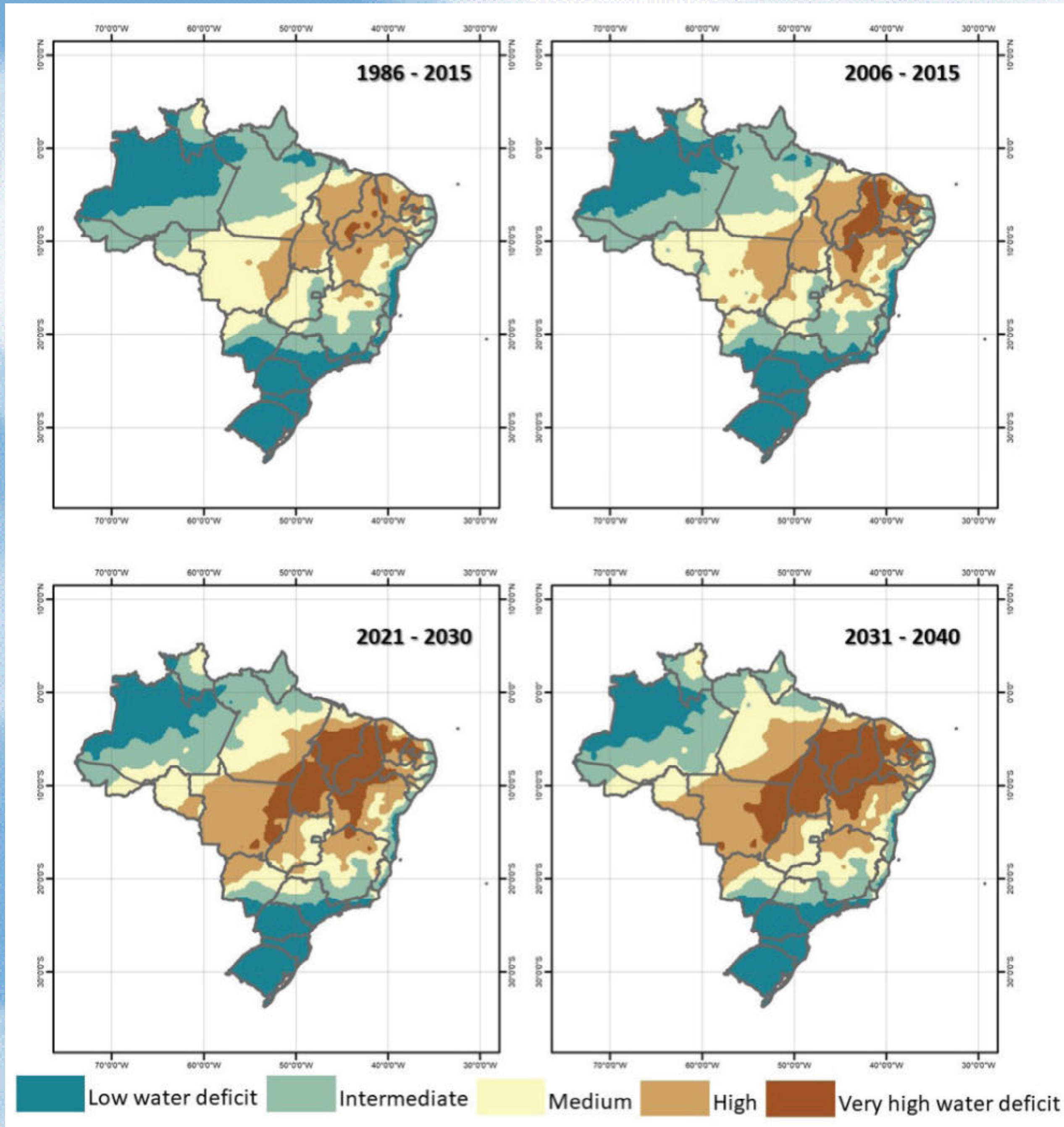
- Observations: ΔT ≈ 1.1 to 1.5ºC
- Deforestation: ≈ 18%
- Forest fire frequency (increasing)
- Lengthening of dry season (increasing)
- Increasing climate extremes

Adapted from Nobre et al., 2015, 2016

Water deficit in Brazil 1986-2040

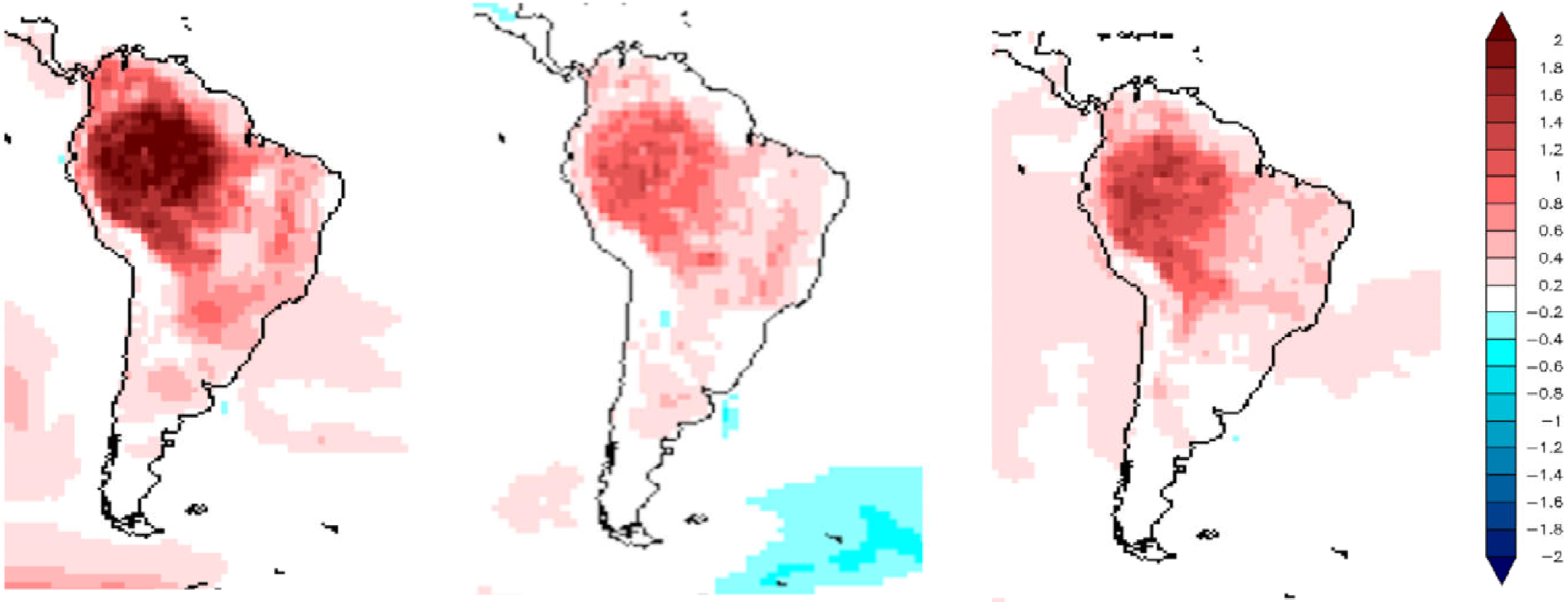
Brazil is already becoming a dryer area

Embrapa Informática Agropecuária, 2019



The world without Amazonia in 2050...

Changes in surface temperature, °C



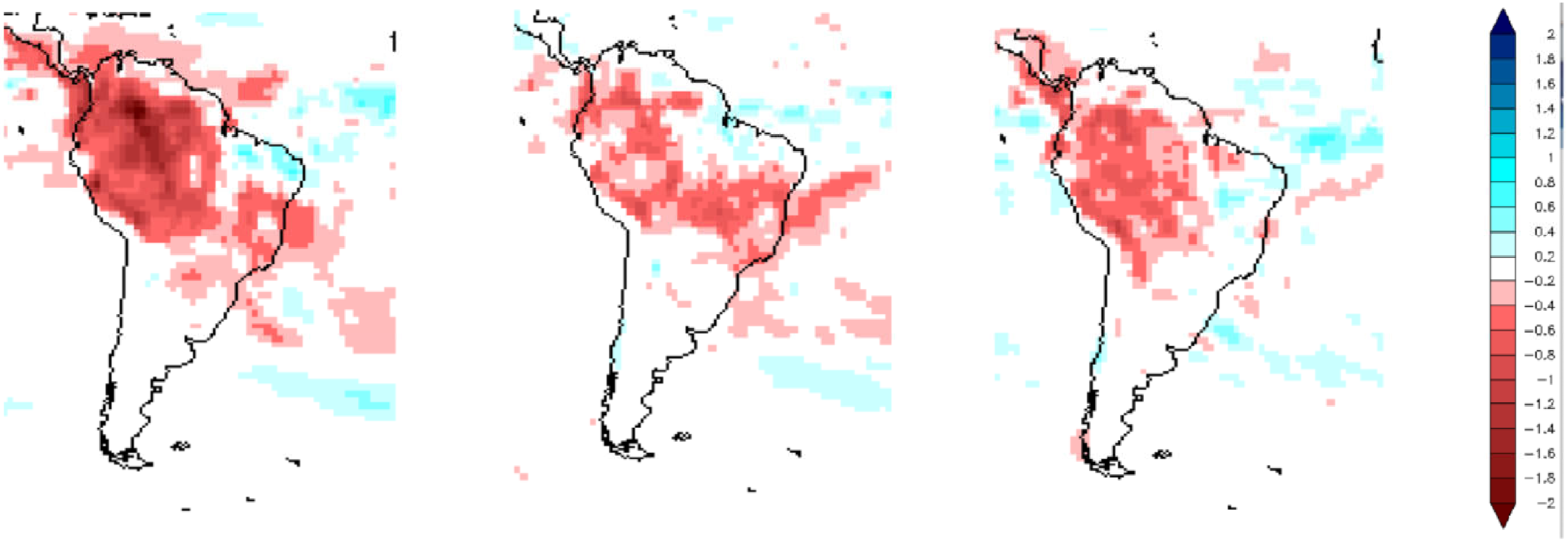
SSP1, 100% SSP1, 50% SSP5, 50%

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

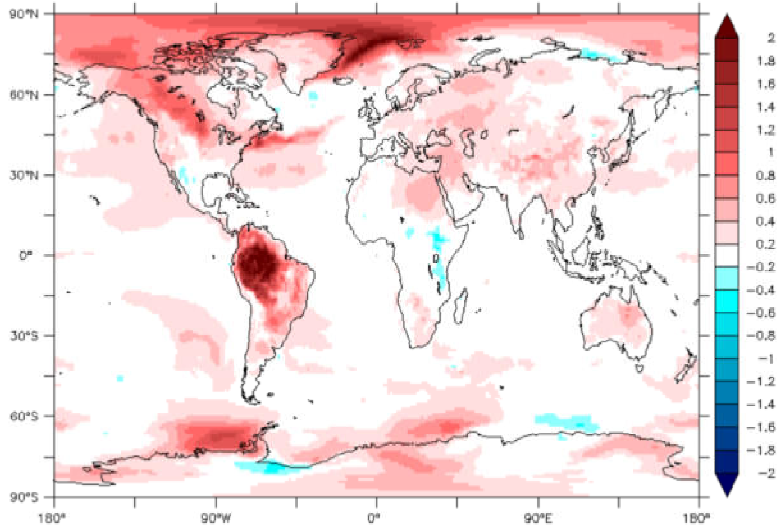


SSP1, 100% SSP1, 50% SSP5, 50%

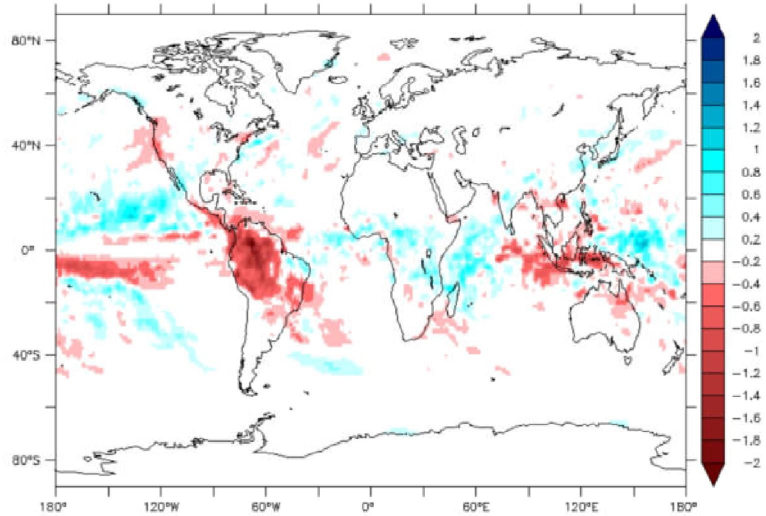
Shevliakova and Pacala - Exploring a World Without the Amazon 2019

The world without Amazonia in 2050…

Global effect under the ambitious pathway (100%)



Temperature change

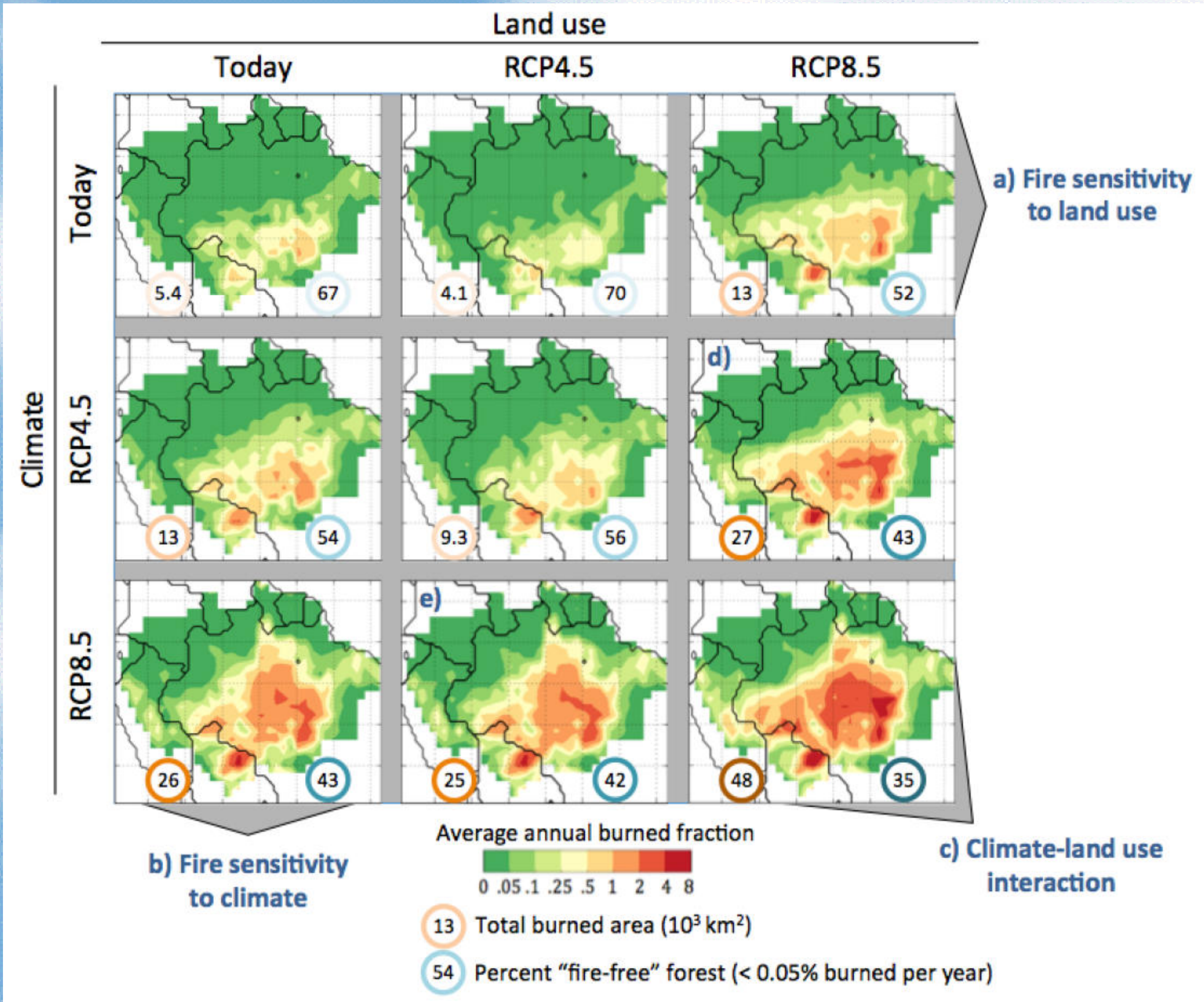


Precipitation change

ΔT increase: 0.25 C, Δ CO_2: 30 ppm

Shevliakova and Pacala - Exploring a World Without the Amazon 2019

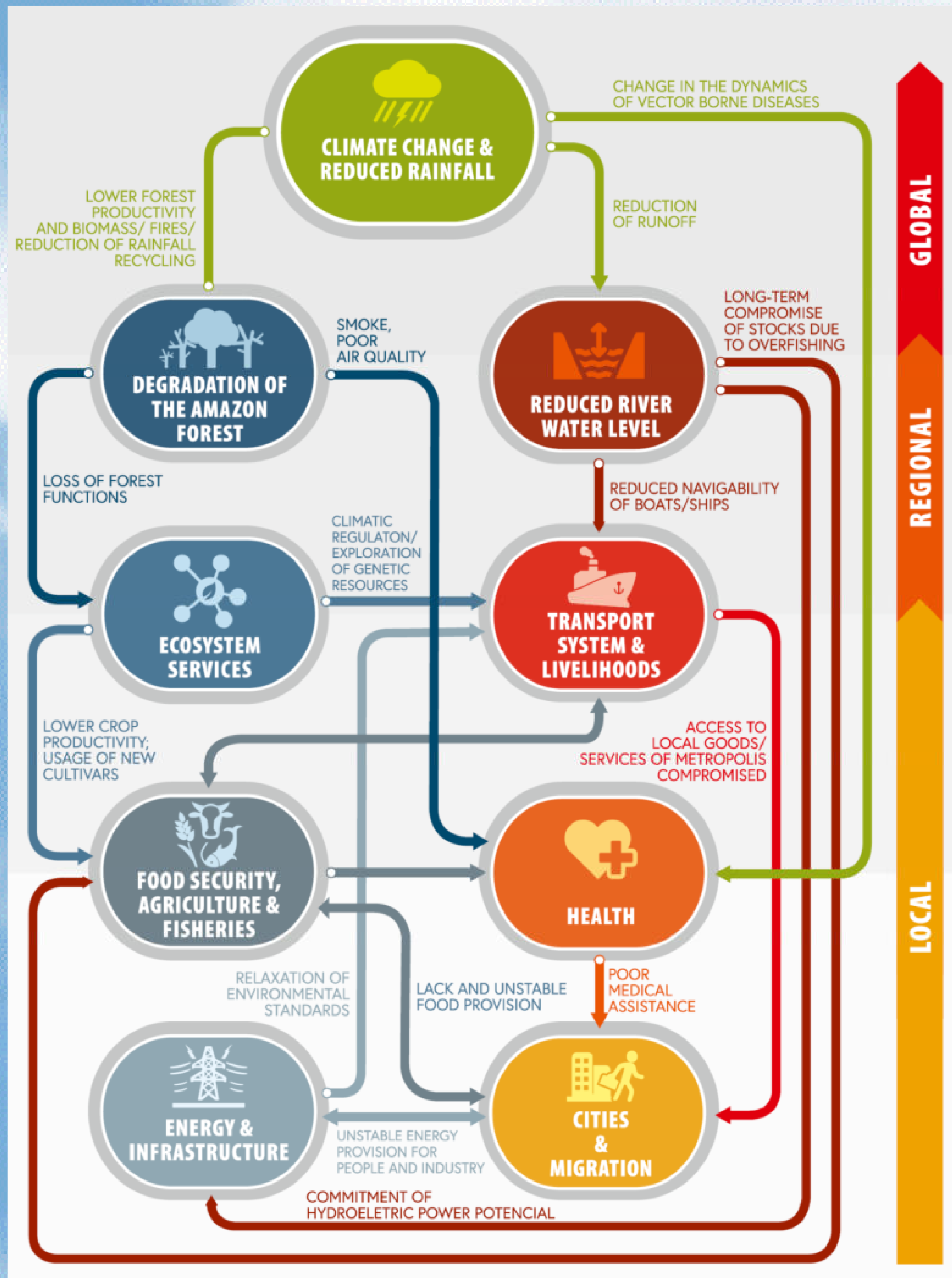
Fire sensitivity to Climate and Land Use



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

Le Page et al., 2017

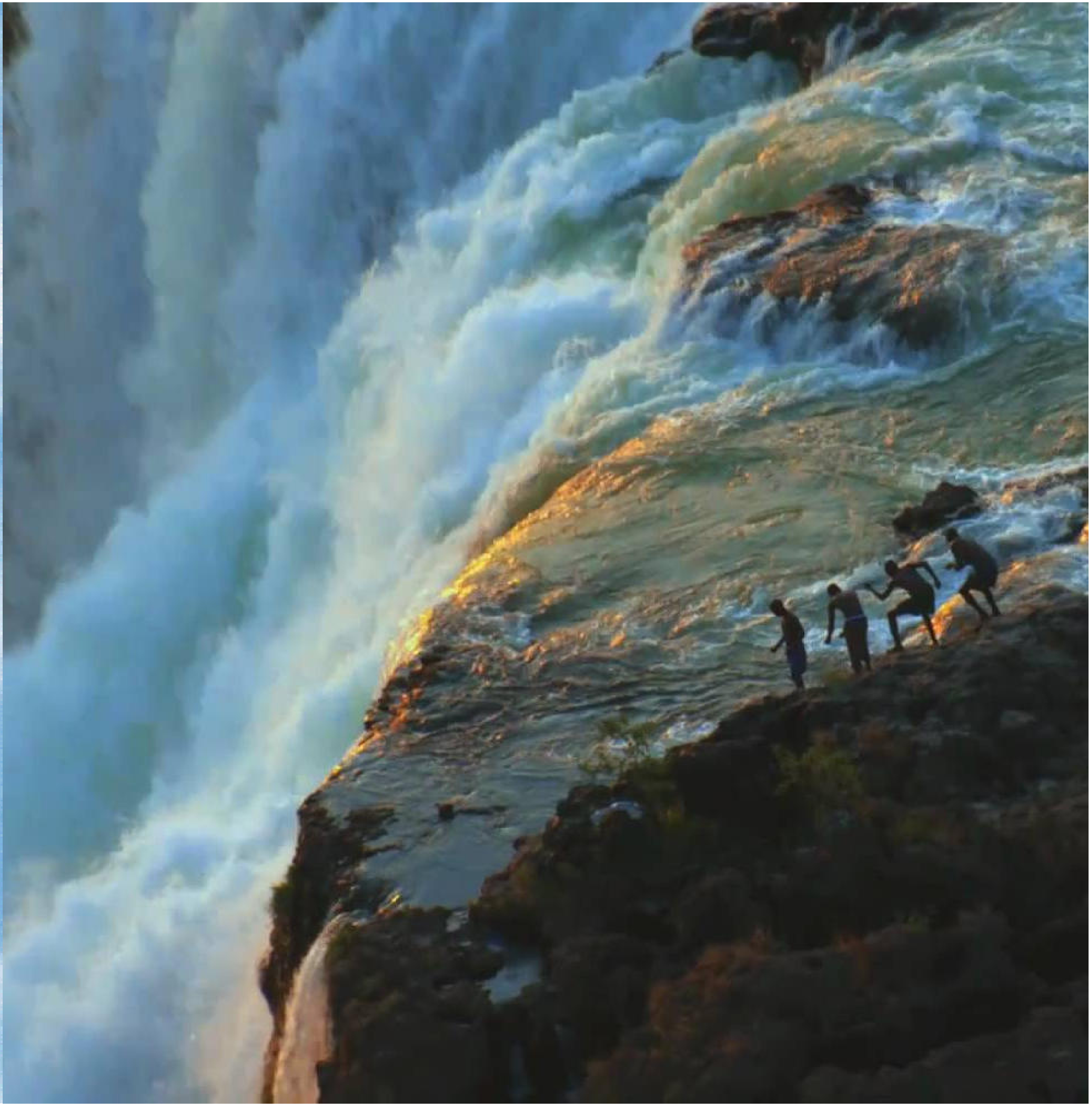
Causal chain of climate change, ecological degradation of the Amazon Forest, and their impacts on different sectors of the regions socioeconomy



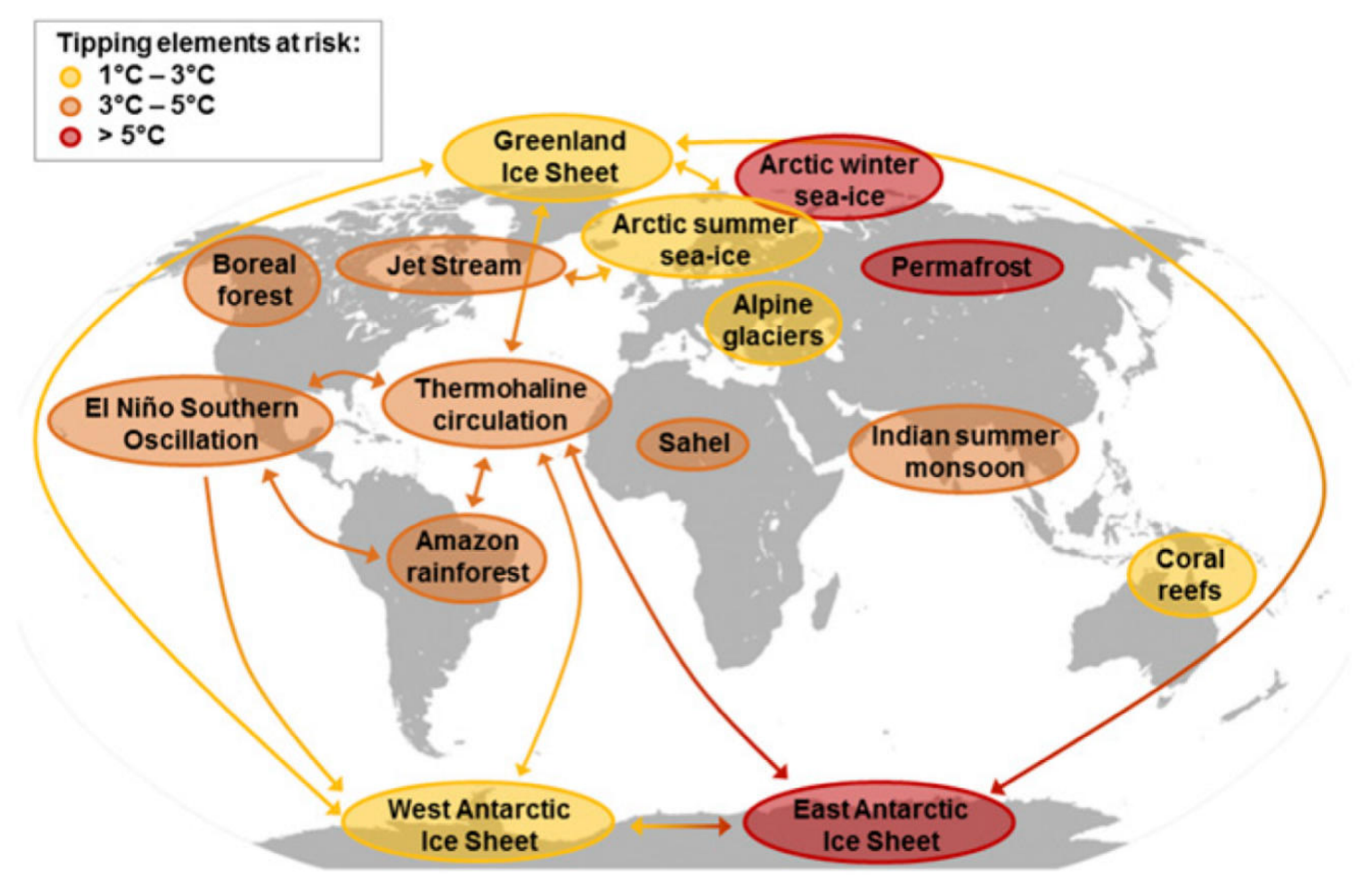
Lapola et al., PNAS Vol,. 115, no. 46-11671-11679
doi: 10.1073/pnas.1721770115

How close to the edge do we dare to get?

The tipping point issue…

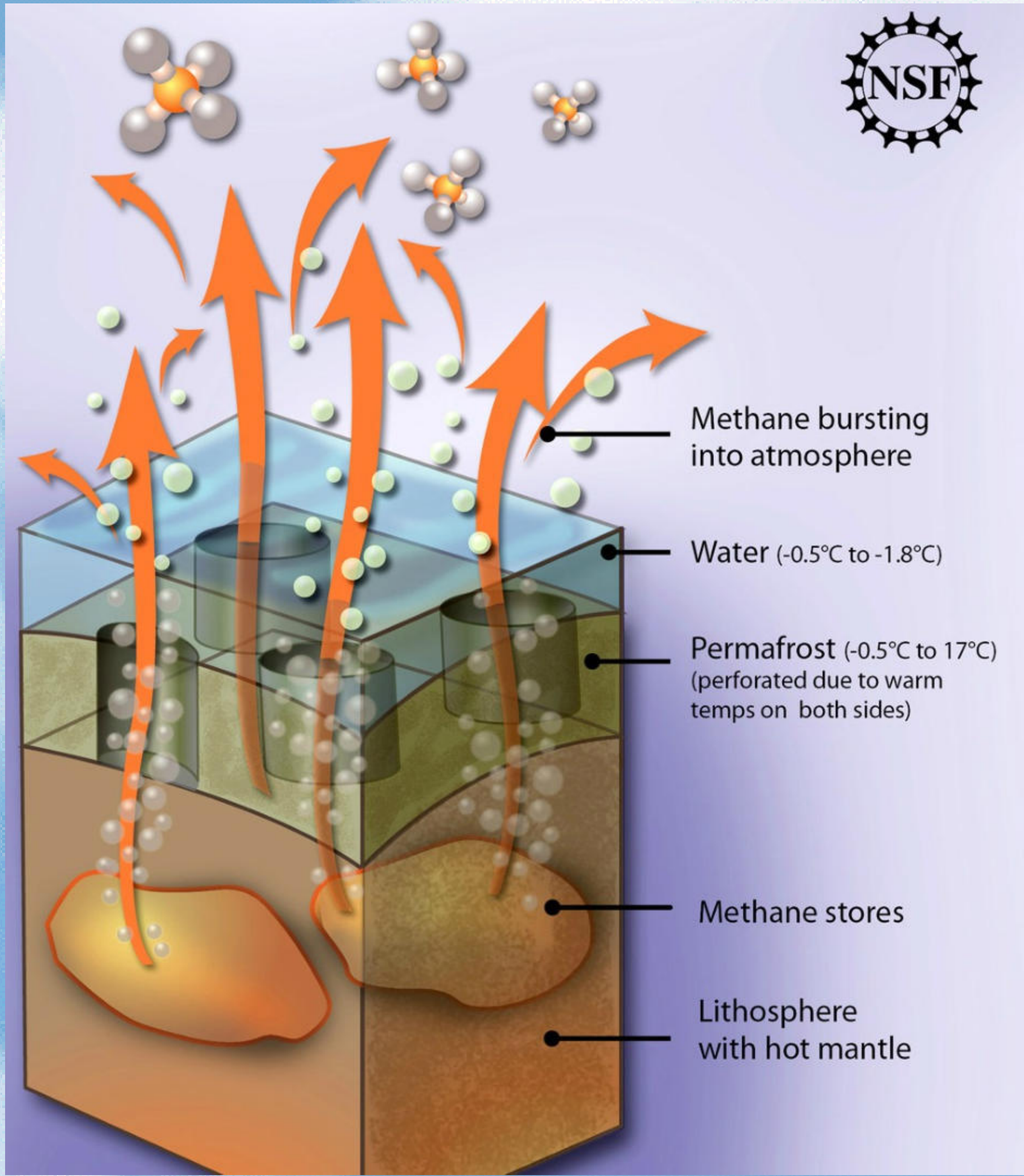


Tipping points of the Earth climate system

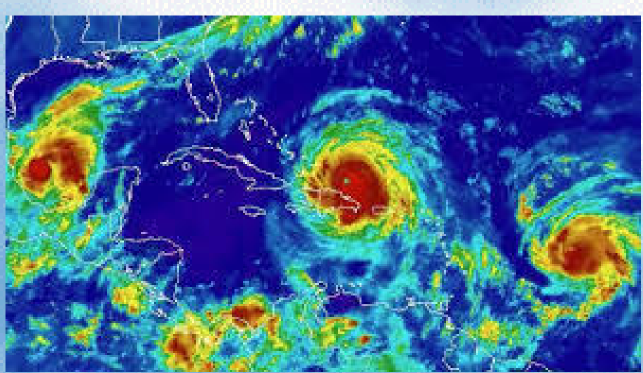


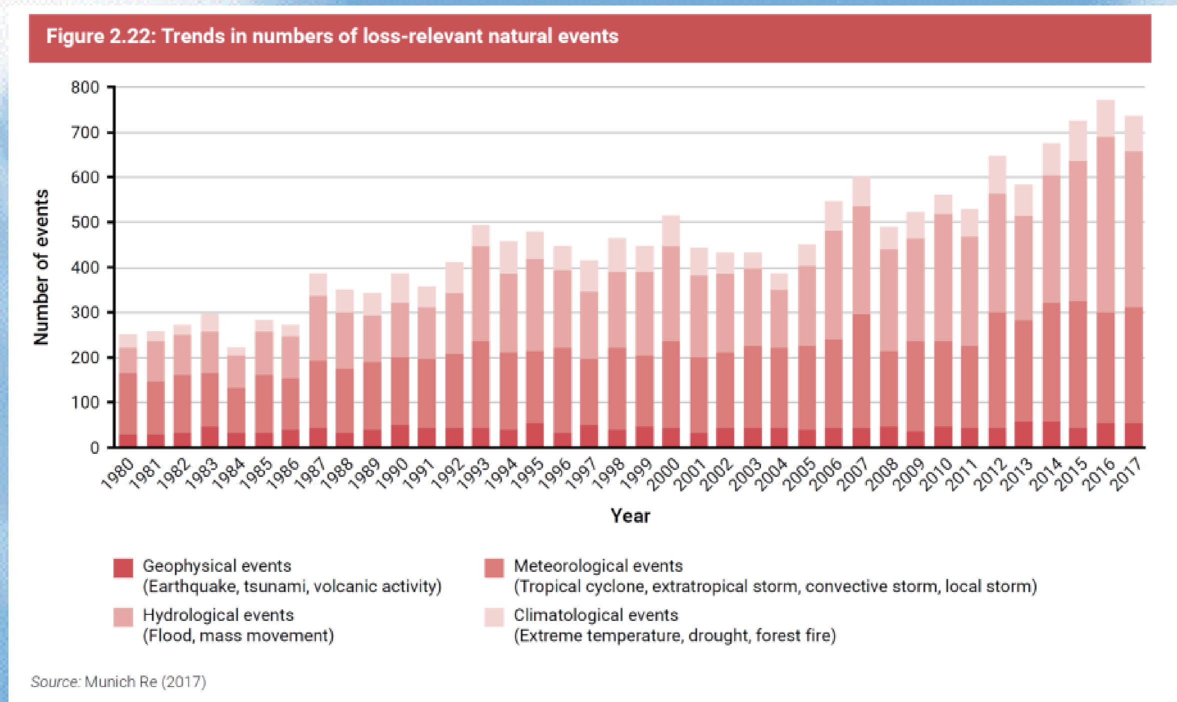
UNEP GEO-6 2019

Feedbacks: Arctic permafrost methane leakage to the atmosphere



Riscos: Aumento na intensidade e frequencia de eventos climáticos extremos

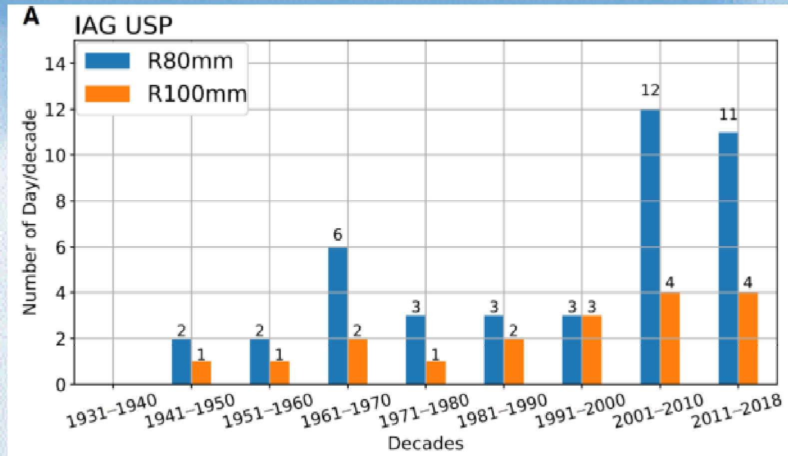




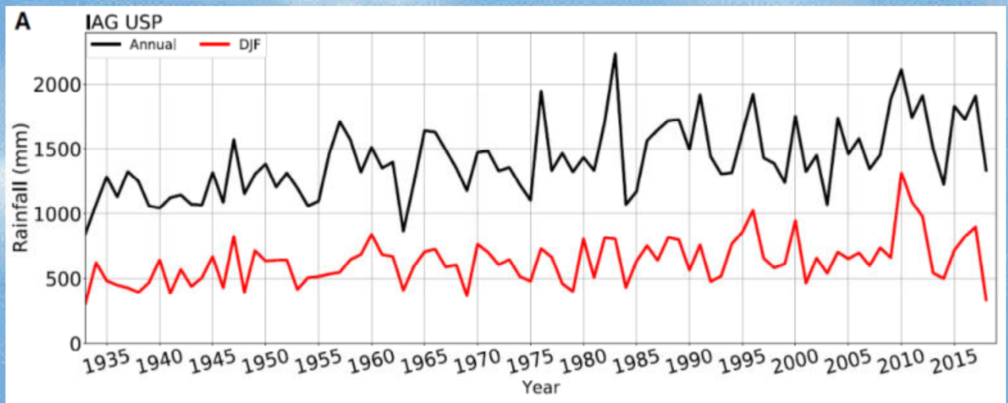
Já está ocorrendo desde a década de 80

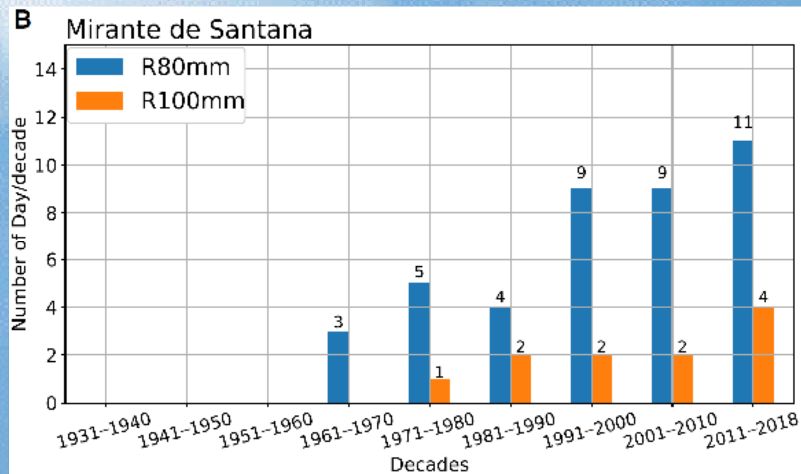
Enchentes em São Paulo e outros centros urbanos no Brasil

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

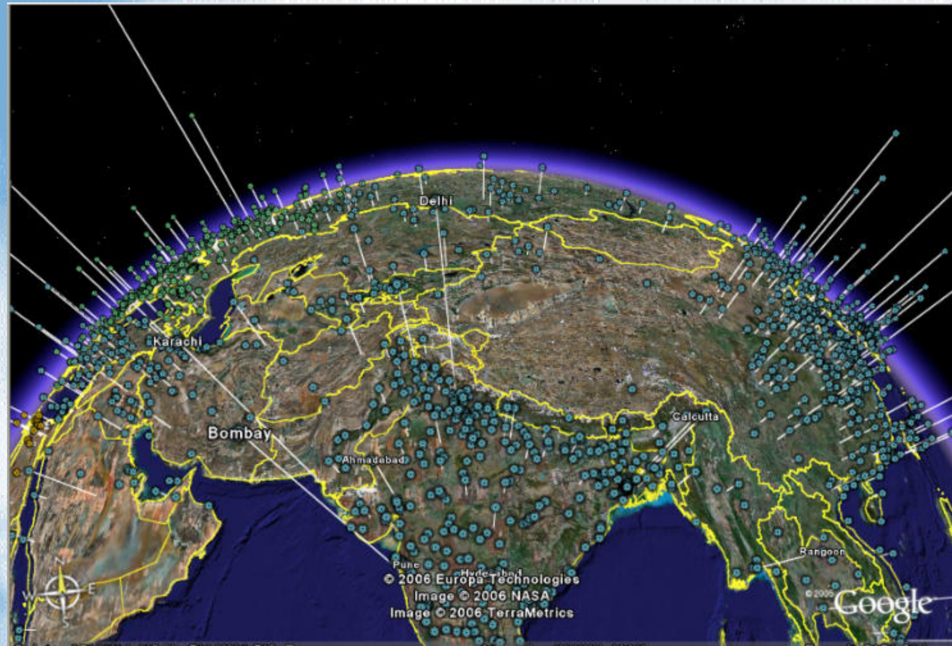


Chuva mensal em São Paulo de 1935 a 2018

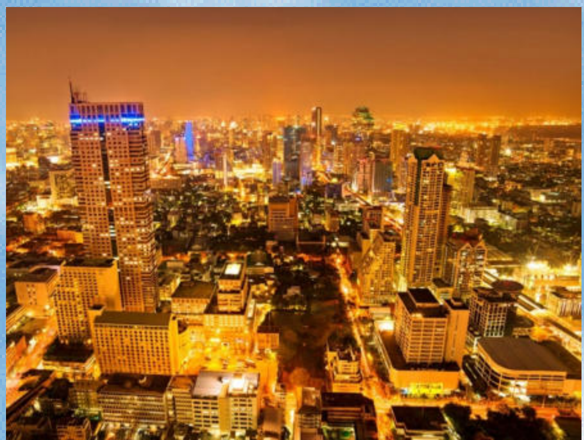




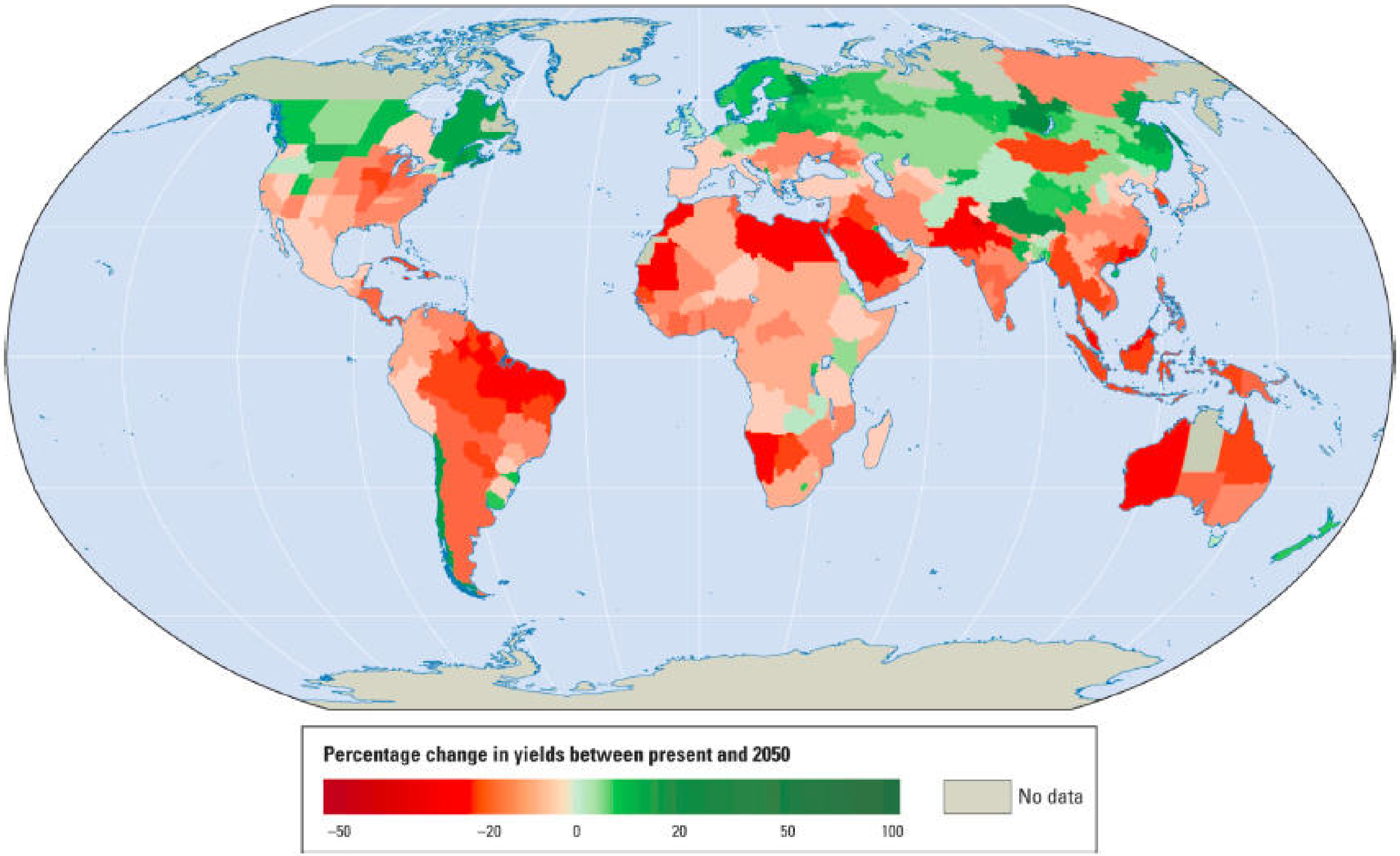
Marengo et al., doi: 10.1111/nyas.14307, Ann N.Y. Acad. Sci. 2020



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



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



World Economic Forum: Global Risks 2016

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

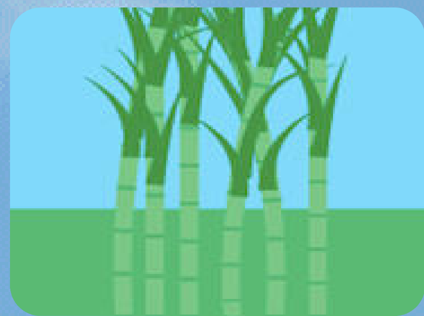
AR5

Produção de energia

Transporte

Agricultura

Biocombustíveis



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
1st	Infrastructure breakdown	Blow up in asset prices	Asset price collapse	Asset price collapse	Storms and cyclones	Income disparity	Income disparity
2nd	Chronic diseases	Middle East instability	China economic slowdown	China economic slowdown	Flooding	Fiscal imbalances	Fiscal imbalances
3rd	Oil price shock	Failed and failing states	Chronic diseases	Chronic disease	Corruption	Greenhouse gas emissions	Greenhouse gas emissions
4th	China hard landing	Oil price shock	Global governance gaps	Fiscal crises	Biodiversity loss	Cyberattacks	Water crises
5th	Blow up in asset prices	Chronic diseases	Deglobalization (emerging)	Global governance gaps	Climate change	Water crises	Population ageing

	2014	2015	2016	2017	2018	2019	2020
1st	Income disparity	Interstate conflict	Involuntary migration	Extreme weather	Extreme weather	Extreme weather	Extreme weather
2nd	Extreme weather	Extreme weather	Extreme weather	Involuntary migration	Natural disasters	Climate action failure	Climate action failure
3rd	Unemployment	Failure of national governance	Climate action failure	Natural disasters	Cyberattacks	Natural disasters	Natural disasters
4th	Climate action failure	State collapse or crisis	Interstate conflict	Terrorist attacks	Data fraud or theft	Data fraud or theft	Biodiversity loss
5th	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
1st	Blow up in asset prices	Blow up in asset prices	Asset price collapse	Asset price collapse	Fiscal crises	Financial failure	Financial failure
2nd	Deglobalization	Deglobalization (developed)	Deglobalization (developed)	Deglobalization (developed)	Climate change	Water crises	Water crises
3rd	Interstate and civil wars	China hard landing	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food crises	Fiscal imbalances
4th	Pandemics	Oil price shock	Chronic diseases	Chronic disease	Asset price collapse	Fiscal imbalances	Weapons of mass destruction
5th	Oil price shock	Pandemics	Fiscal crises	Fiscal crises	Energy price volatility	Energy price volatility	Climate action failure

	2014	2015	2016	2017	2018	2019	2020
1st	Fiscal crises	Water crises	Climate action failure	Weapons of mass destruction	Weapons of mass destruction	Weapons of mass destruction	Climate action failure
2nd	Climate action failure	Infectious diseases	Weapons of mass destruction	Extreme weather	Extreme weather	Climate action failure	Weapons of mass destruction
3rd	Water crises	Weapons of mass destruction	Water crises	Water crises	Natural disasters	Extreme weather	Biodiversity loss
4th	Unemployment	Interstate conflict	Involuntary migration	Natural disasters	Climate action failure	Water crises	Extreme weather
5th	Infrastructure breakdown	Climate action failure	Energy price shock	Climate action failure	Water crises	Natural disasters	Water crises

Economic | Environmental | Geopolitical | Societal | Technological

2020

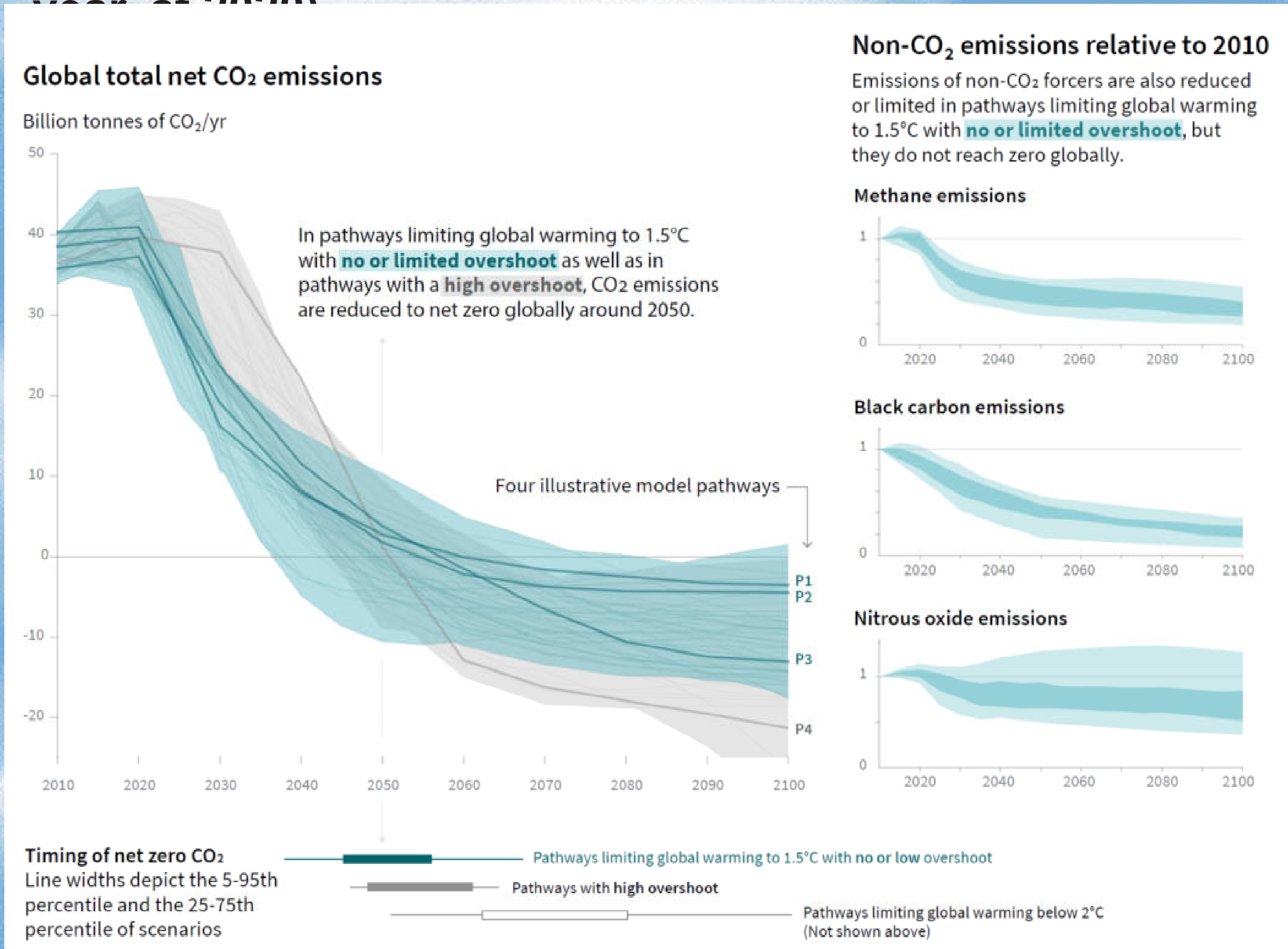
- Extreme weather
- Climate action failure
- Natural disasters
- Biodiversity loss
- Human-made environmental disasters

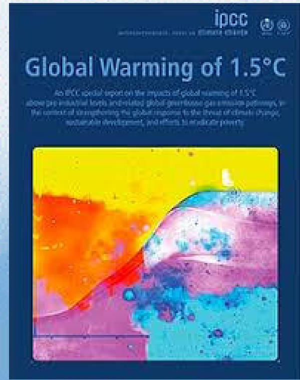
P.S.: Não são preocupações de cientistas, ONGs ou grupos ambientais, mas do WEF…

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 CO2 emissions (-3 % per year, at 2020)





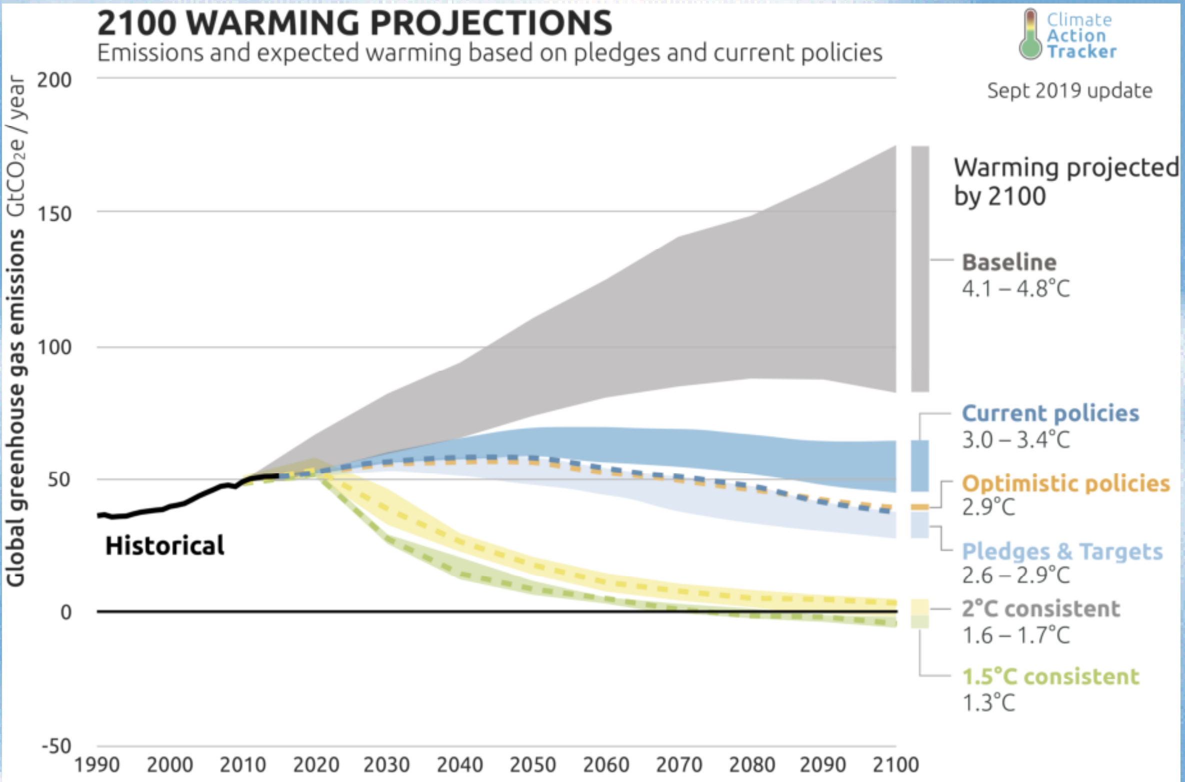
70% Methane reductions

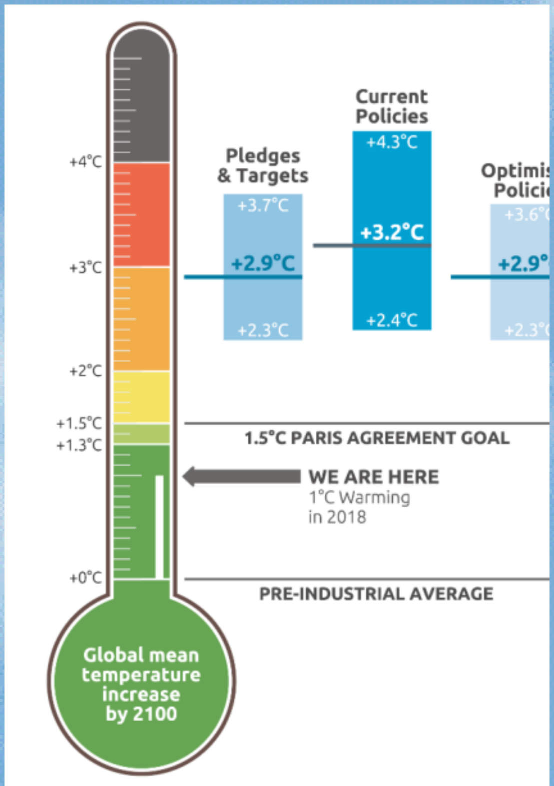
90% Black Carbon reductions

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

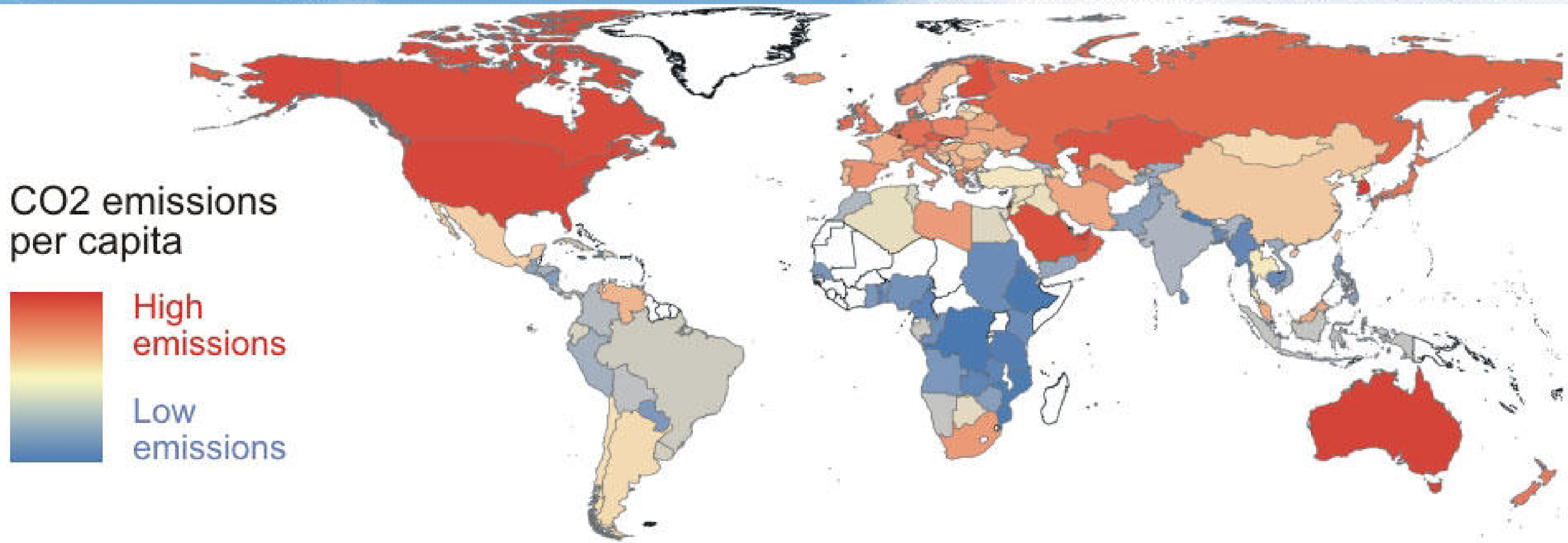
- **Simple and realistic accounting with Paris Agreement: 3.2 degrees average heating**
- **In continental areas: 4.2 C**
- **Removal of regional air pollution: + 0.7 C, makes 4.9 C**
- **80% of population will be urban: Urban heat island: additional 1.0 C, makes 5.9 C**
- **We are heading to : 5.9 C where people live (in cities)**

Governance is a critical issue

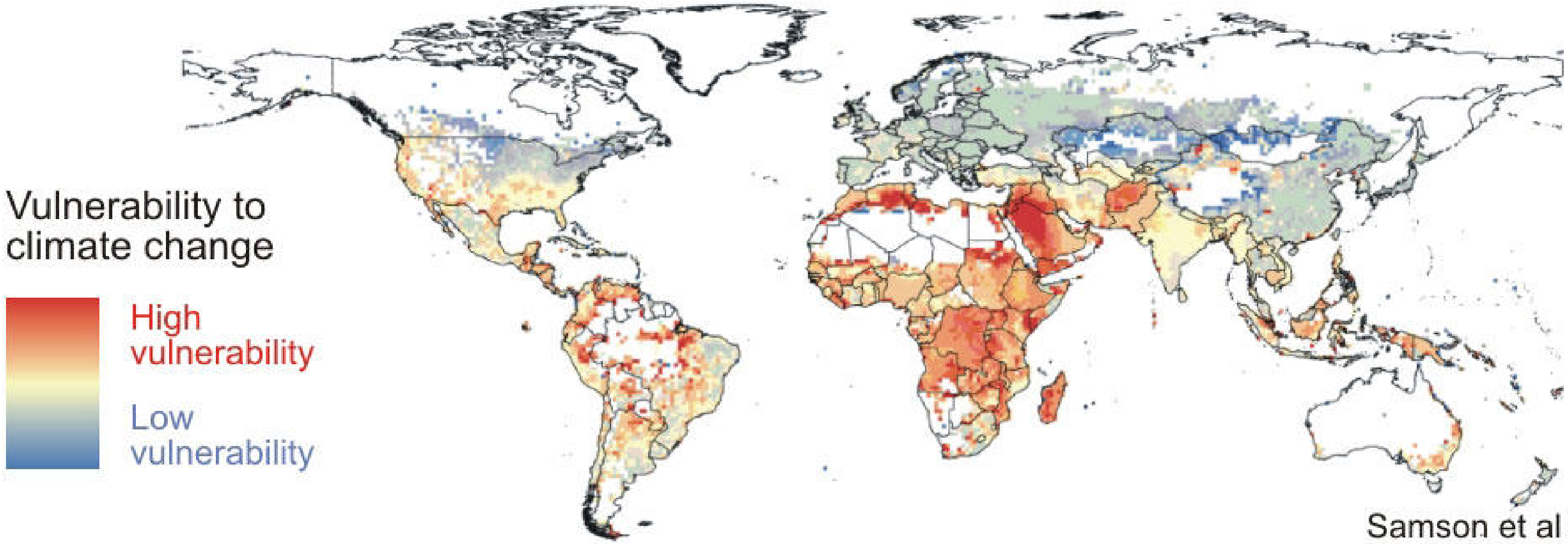
Stephen Hawking "Our planet and the human race face multiple challenges. These challenges are global and serious – climate change, food production, overpopulation, the decimation of other species, epidemic disease, acidification of the oceans. Such pressing issues will require us to collaborate, all 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?



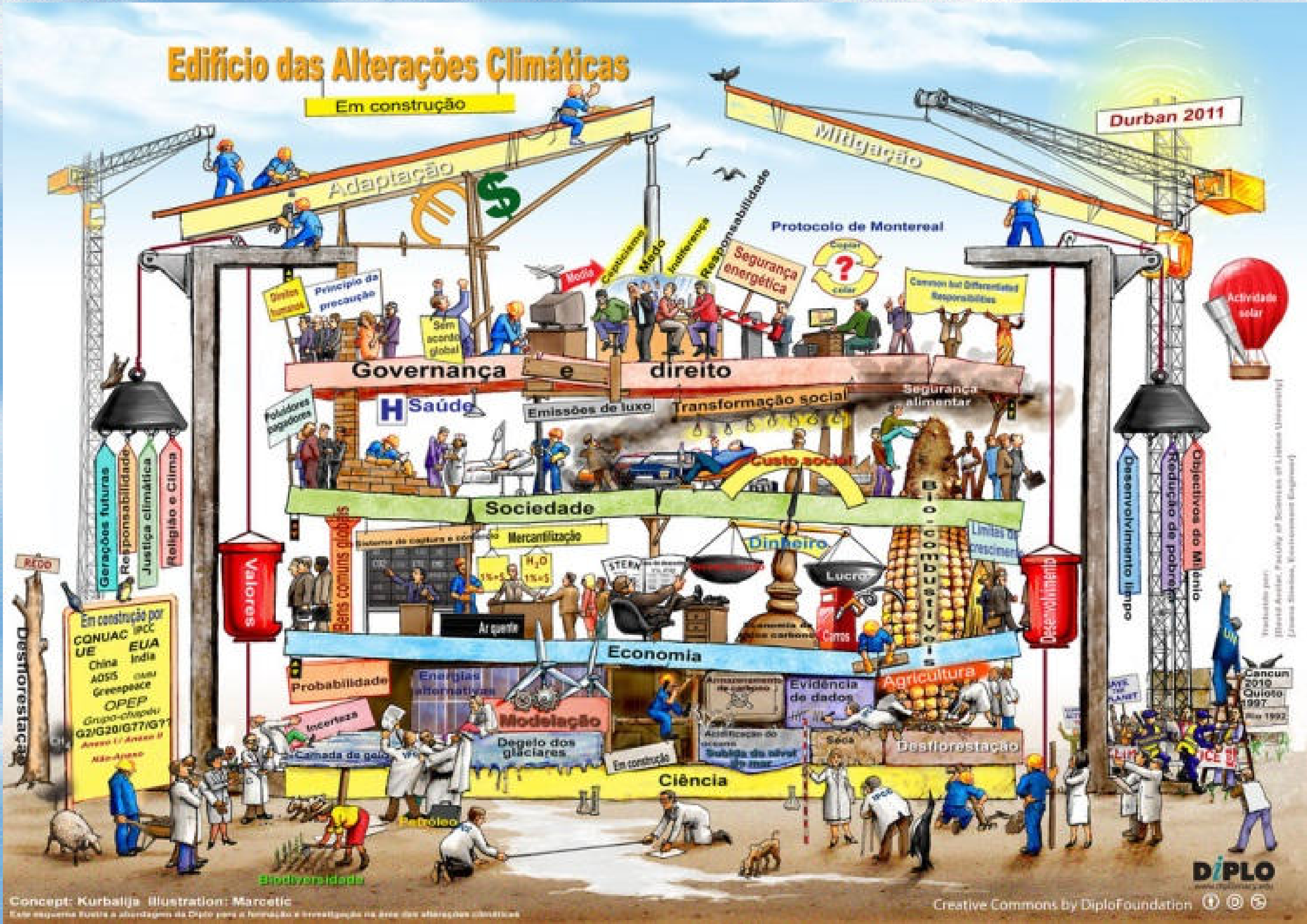
Those who contribute the least greenhouse gases
will be most impacted by climate change



Samson et al 2011

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

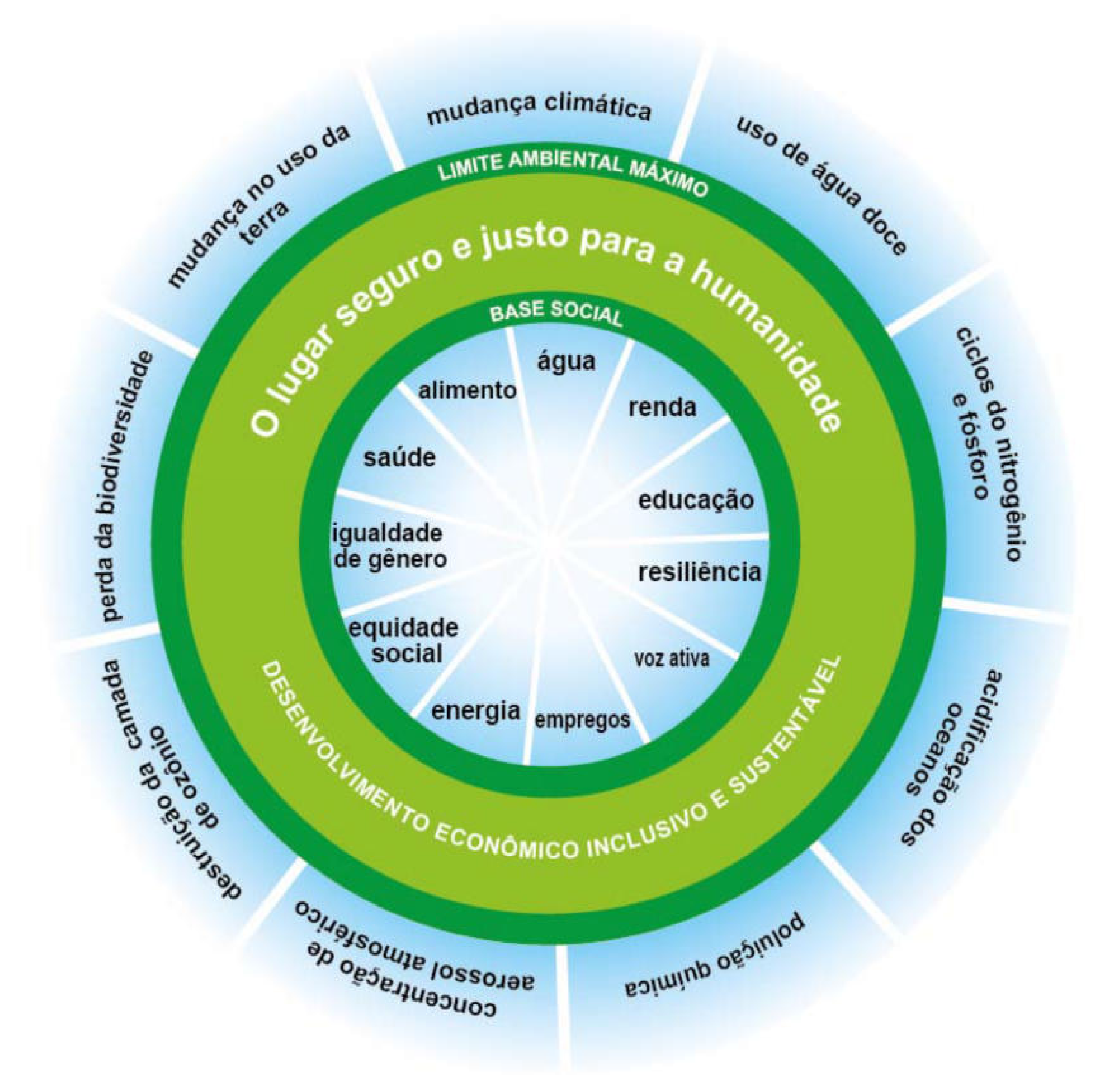
Os 17 objetivos do desenvolvimento sustentável adotados pela ONU

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

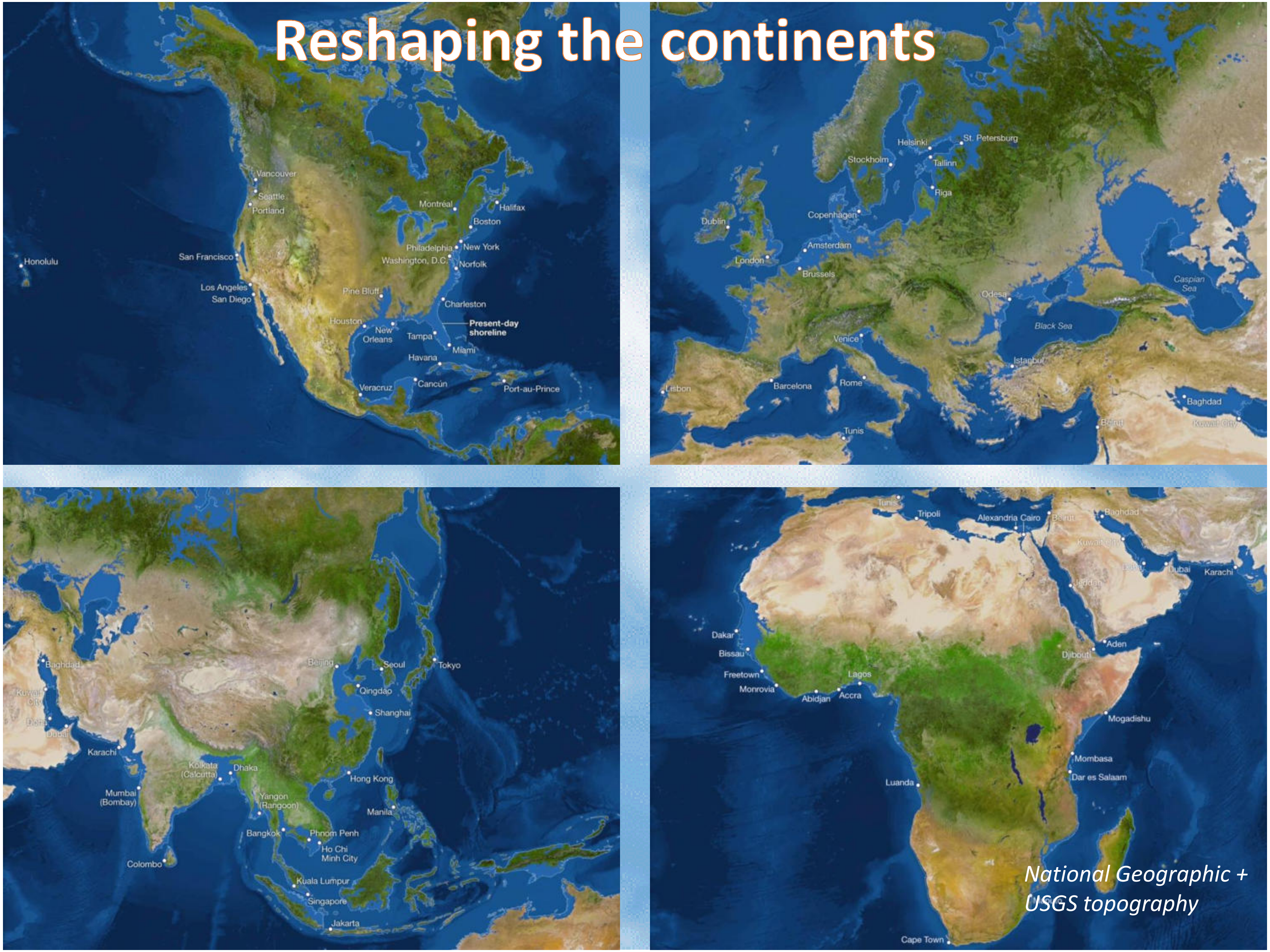


Steffen et al. 2015, Science

Precisamos de sólida ciência interdisciplinar para construir este espaço

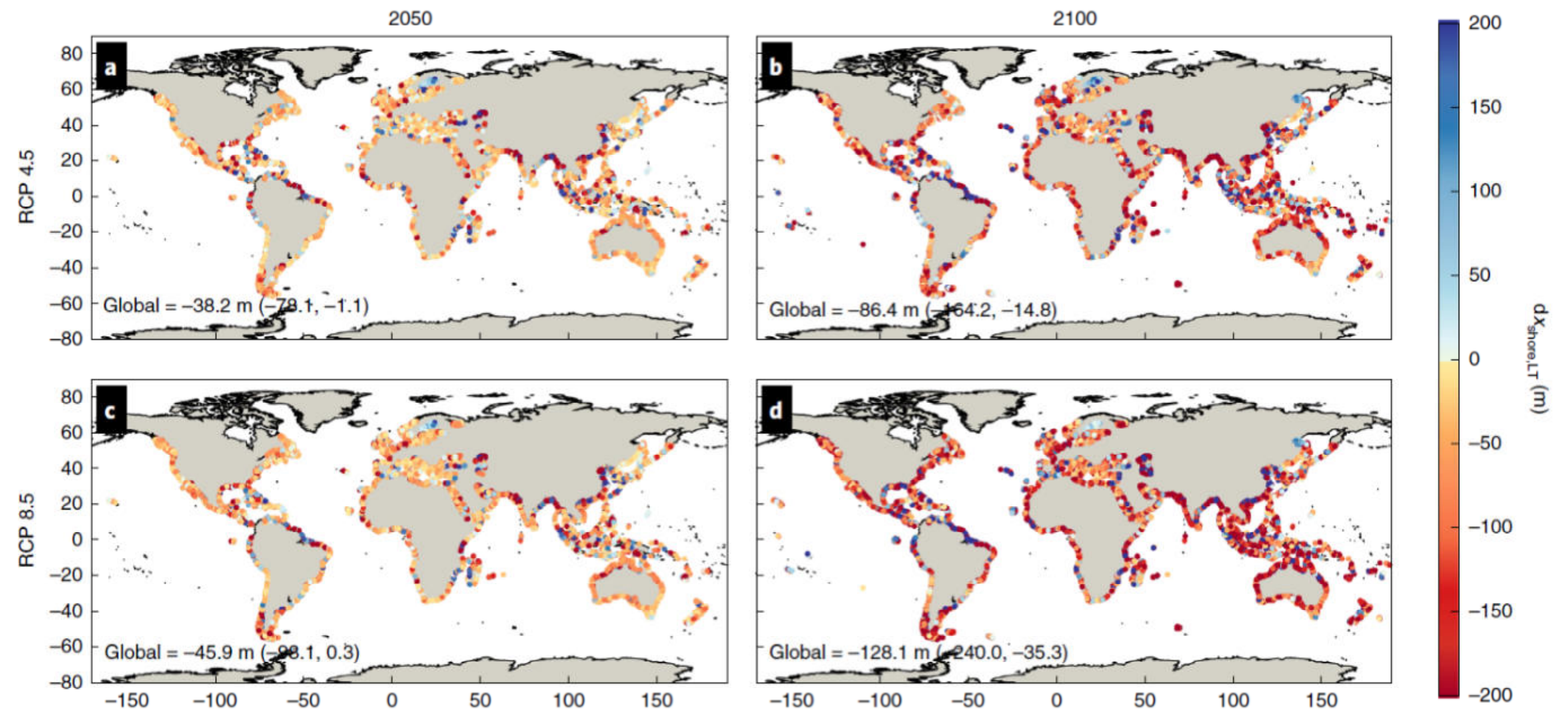

Precisamos de ciência sólida em todas as áreas para encontrar meios de usar os recursos naturais de nosso planeta de modo mais eficiente e inteligente.
Obrigado pela atenção!!!

Reshaping the continents



National Geographic + USGS topography

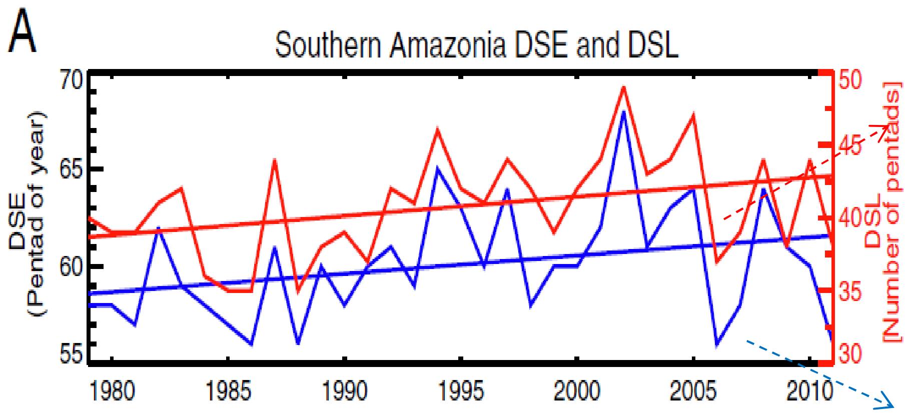
Mudanças na extensão das praias em 2050 e 2100



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

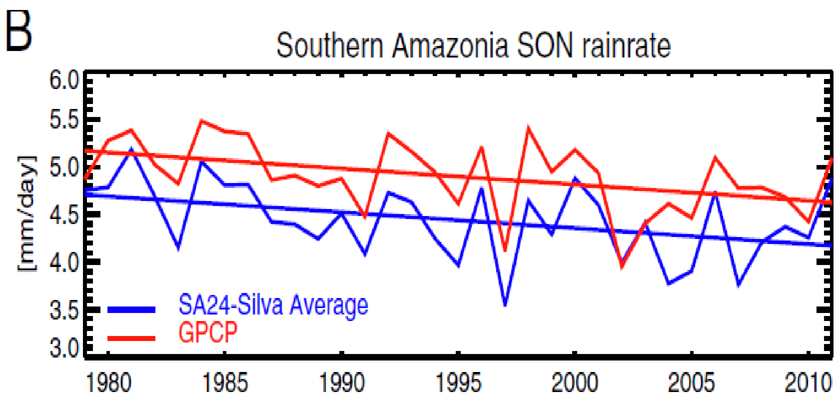
Nature Climate Change Março 2020, https://doi.org/10.1038/s41558-020-0697-0

Dry season length is increasing in Amazonia



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

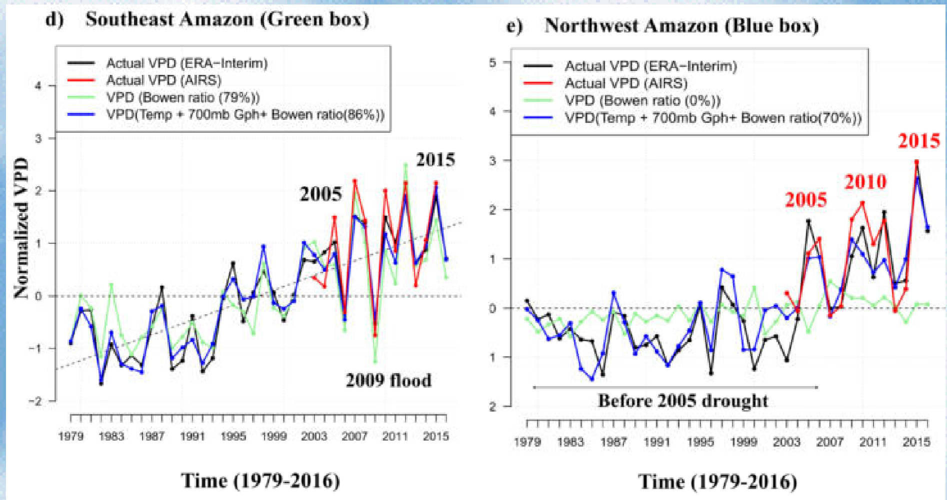
Annual time series of **dry season** END (DSE)

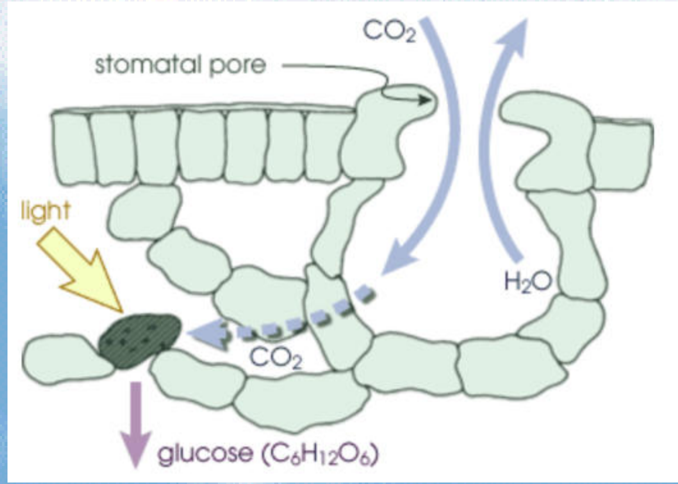


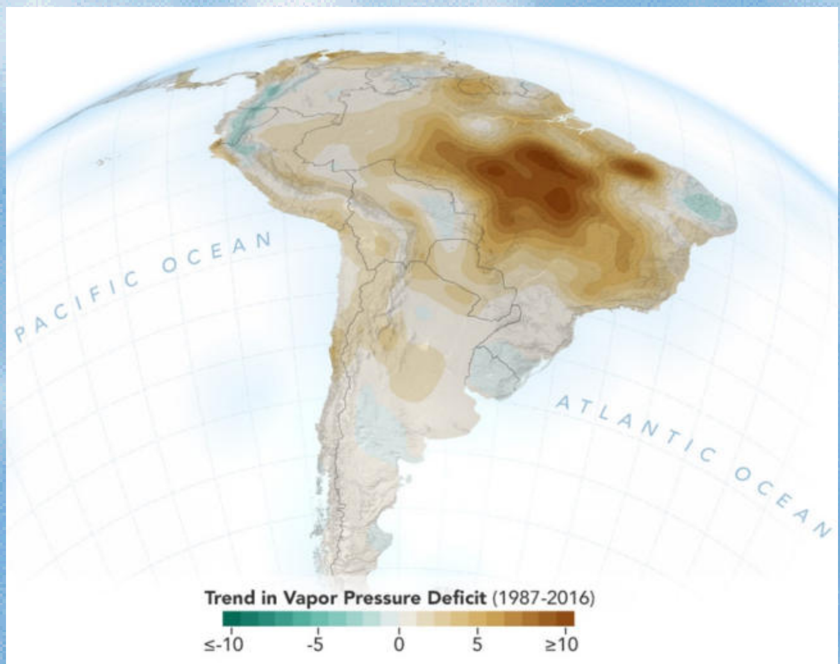
Dry season length has increased by **6.5±2.5** days/decade;

Fu et al. 2013 (PNAS)

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





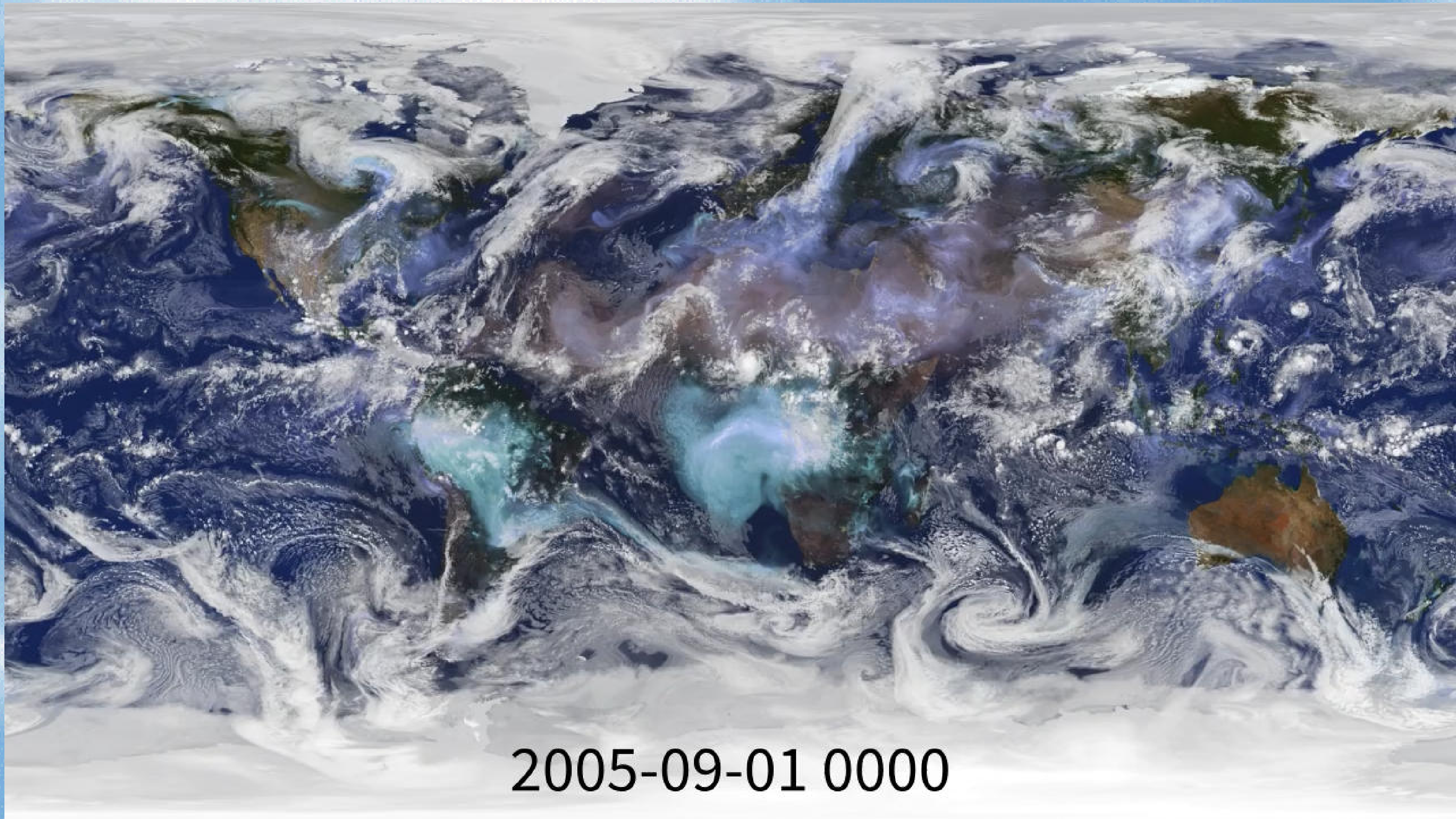


O déficit da pressão de vapor ou VPD é a diferença entre a quantidade de umidade no ar e quanta umidade o ar pode conter quando está saturado

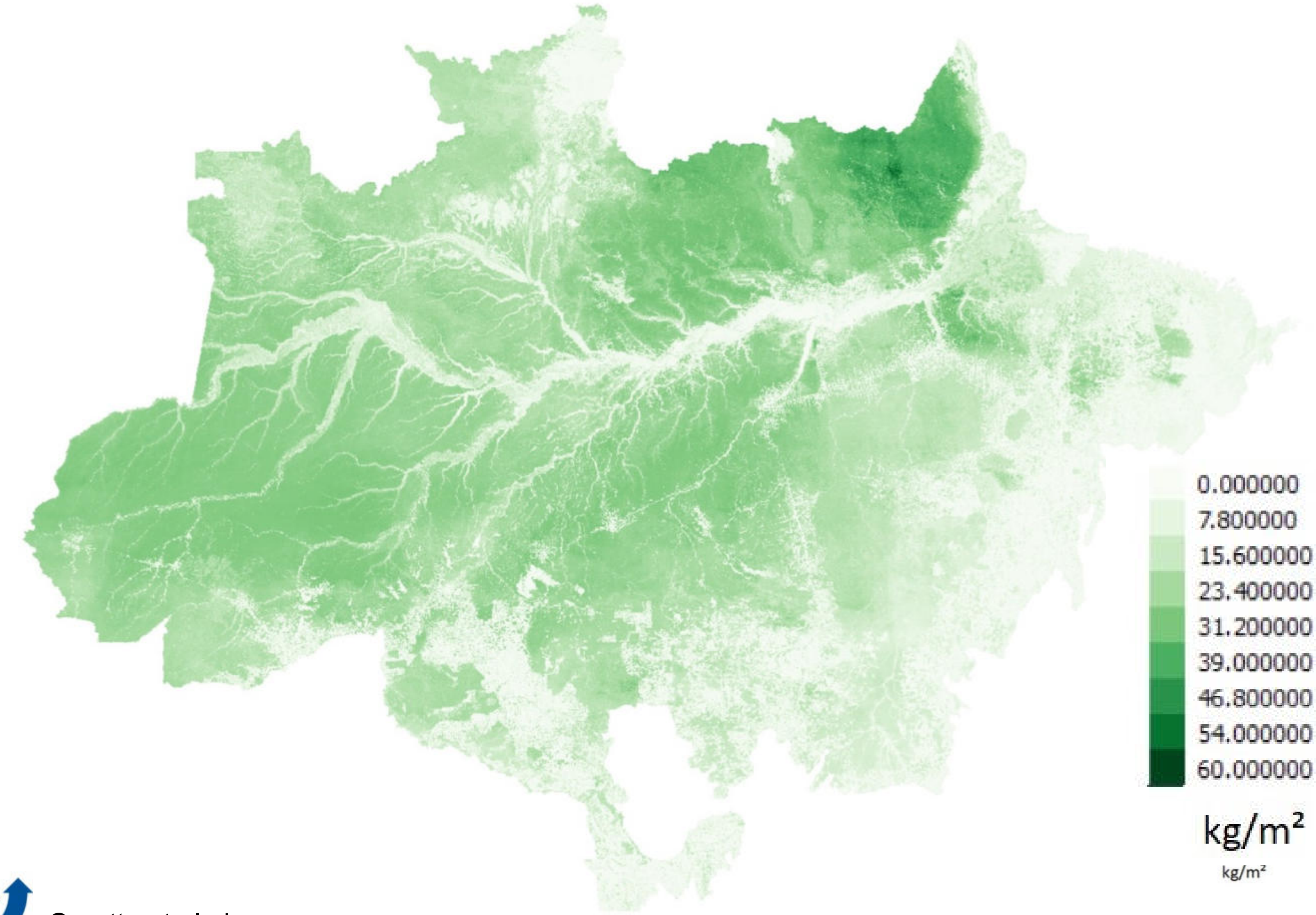
O aumento da VPD combinado com o decréscimo da fração evaporativa são as primeiras indicações de mecanismos de feedback positivos na Amazônia.

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

A complexidade das nuvens no sistema climático



Amazon forest biomass distribution map in Kg/m²



Ometto et al., in press

nature

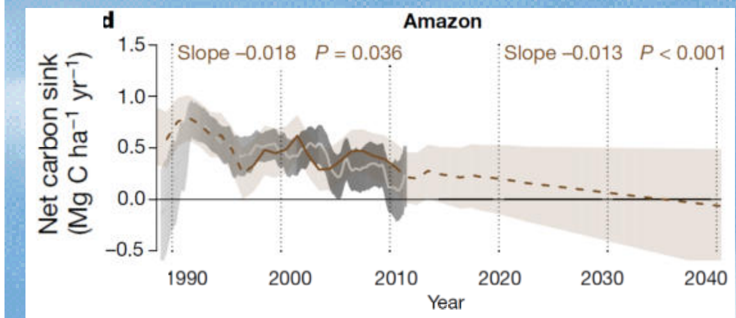
March 5, 2020

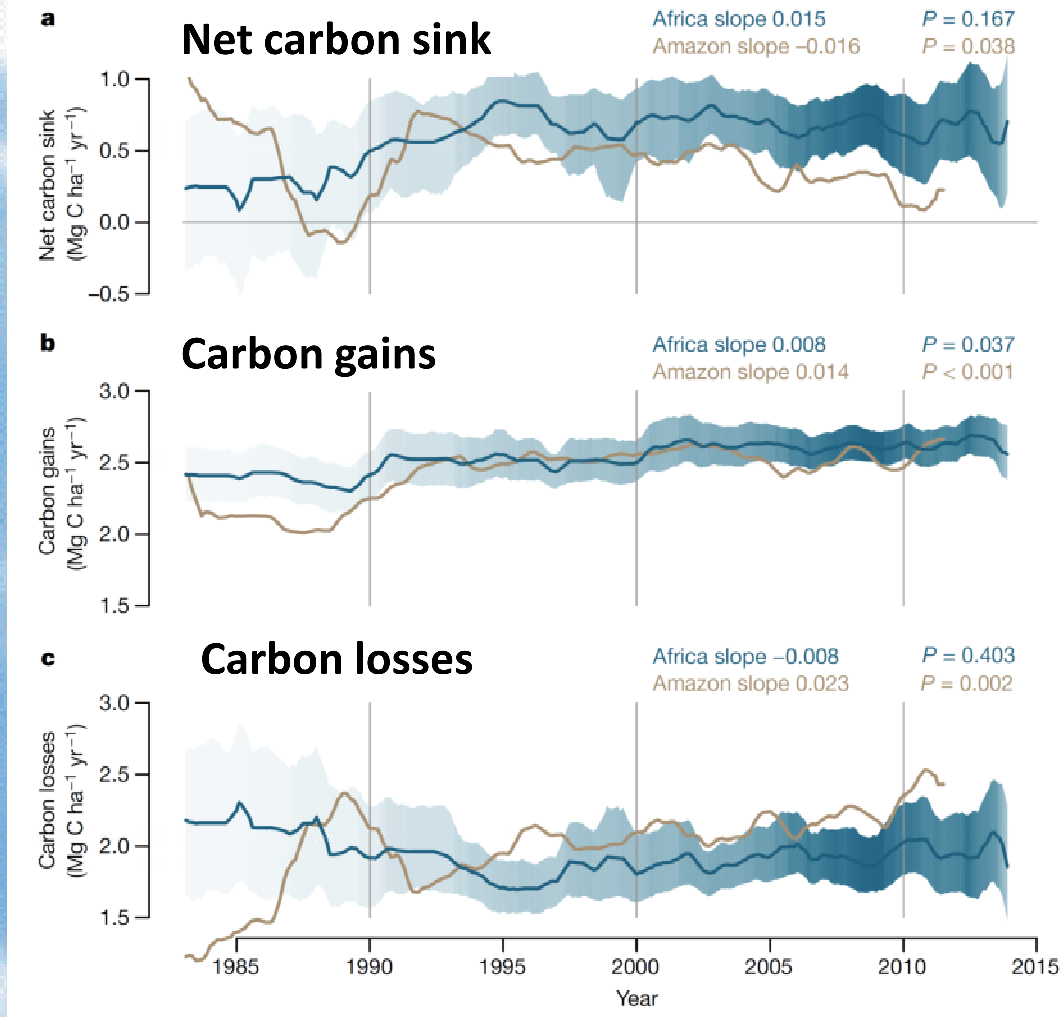
Article

Asynchronous carbon sink saturation in African and Amazonian tropical forests

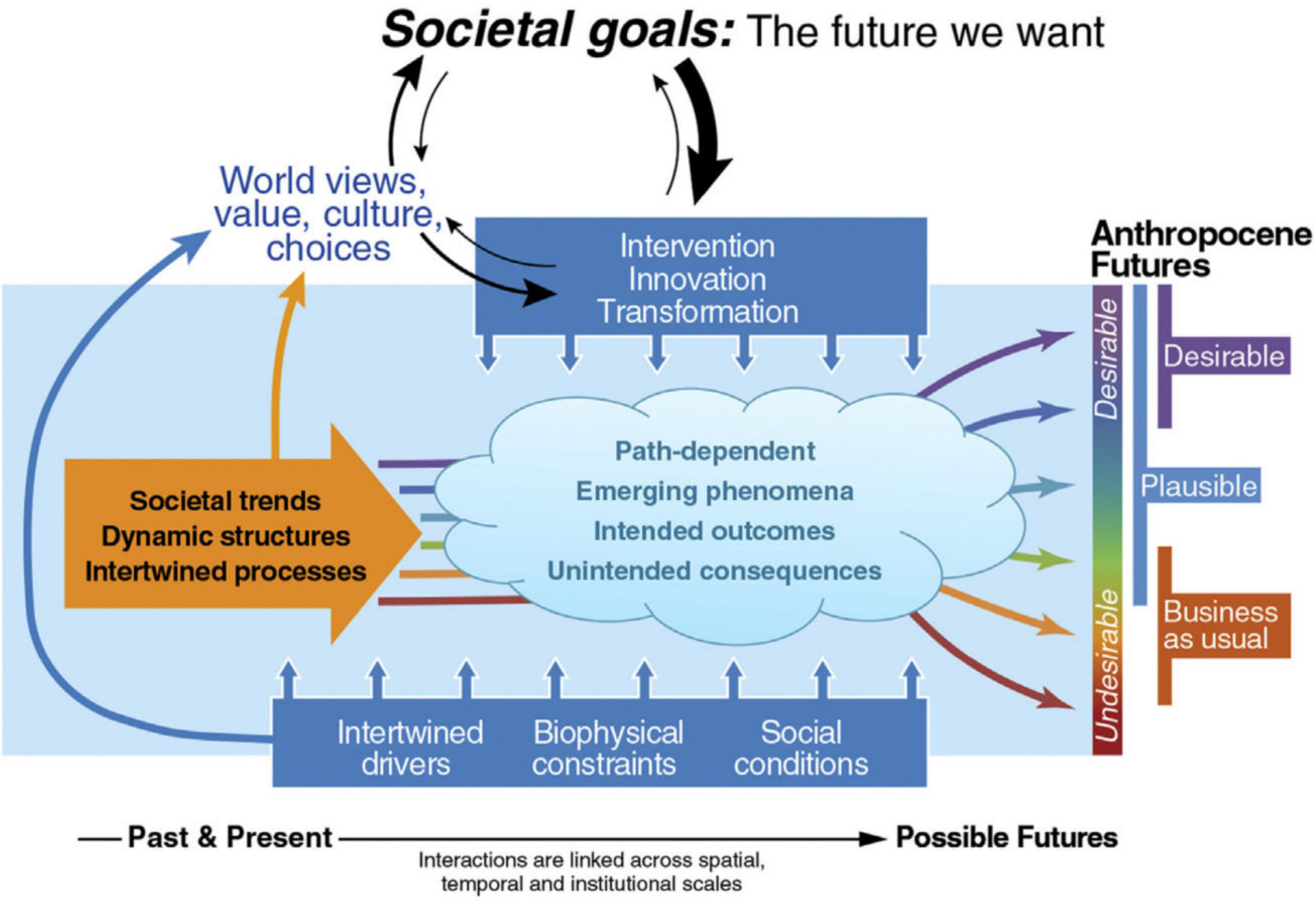
Long-term carbon dynamics of structurally intact oldgrowth tropical forests in Africa and Amazonia.

Net Carbon sink 1990-2040

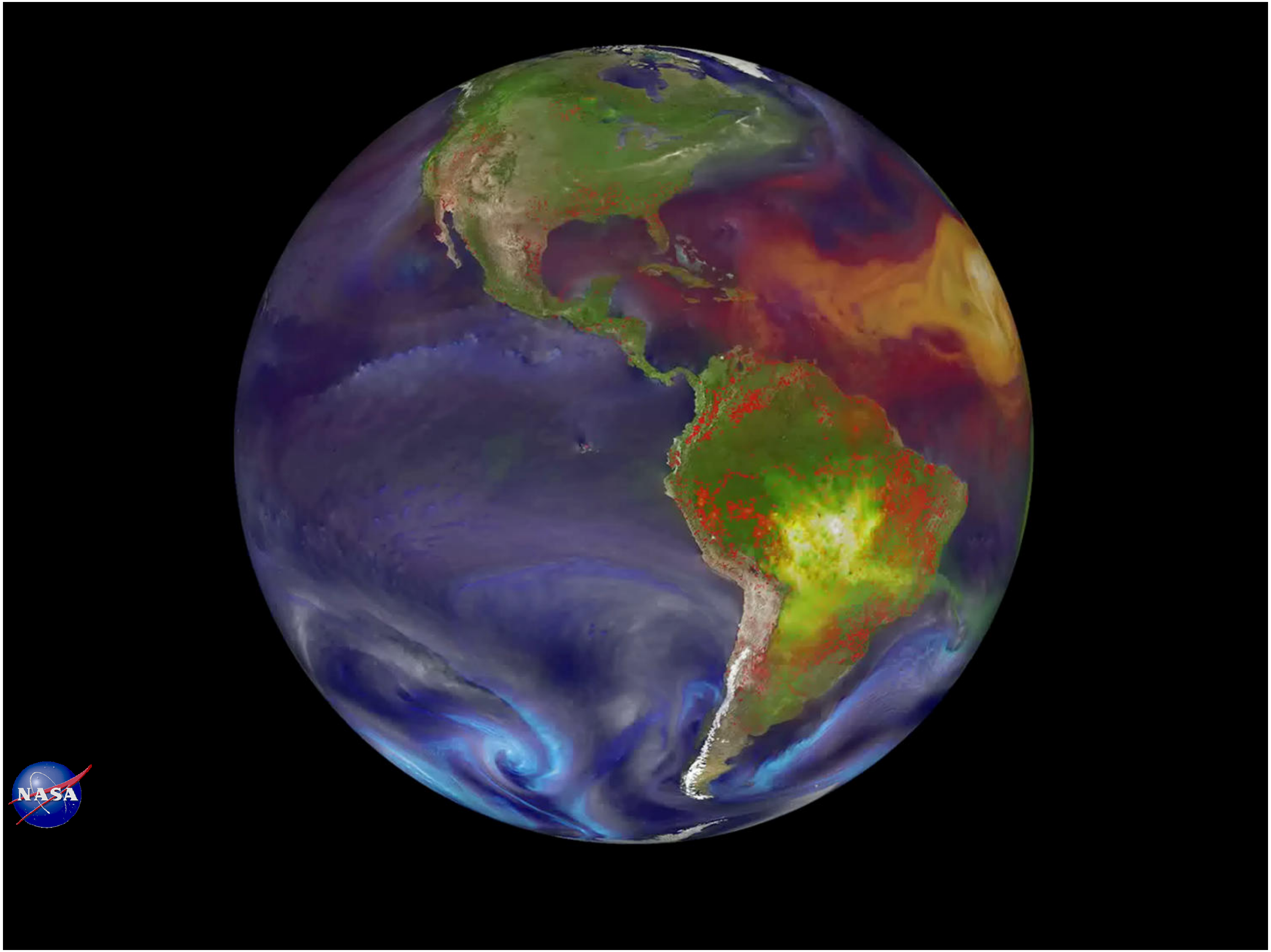




Qual o futuro que queremos? O futuro do Antropoceno

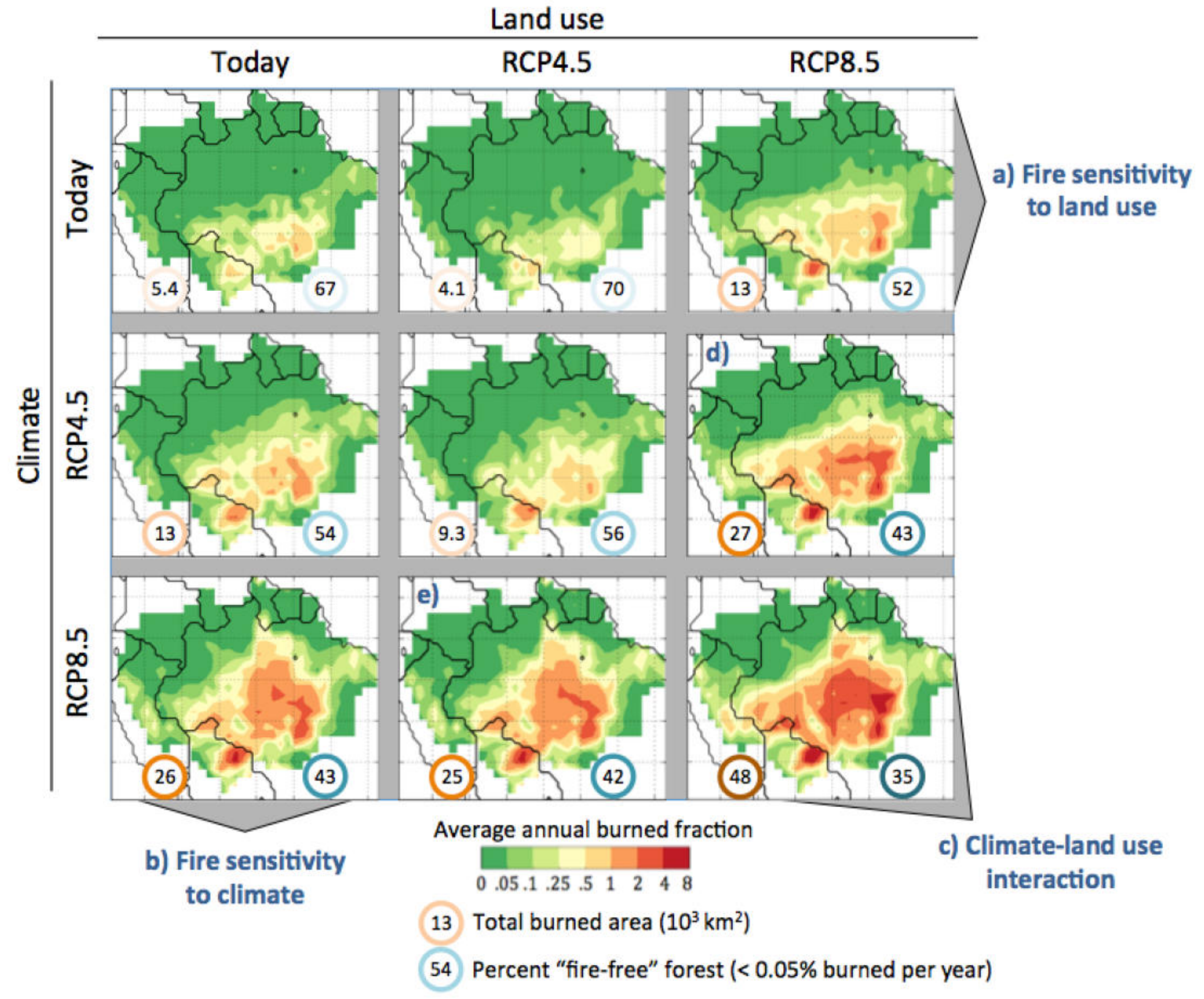


Global Environmental Change 39 (2016) 351–362


NASA

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

Brazilian iNDC

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

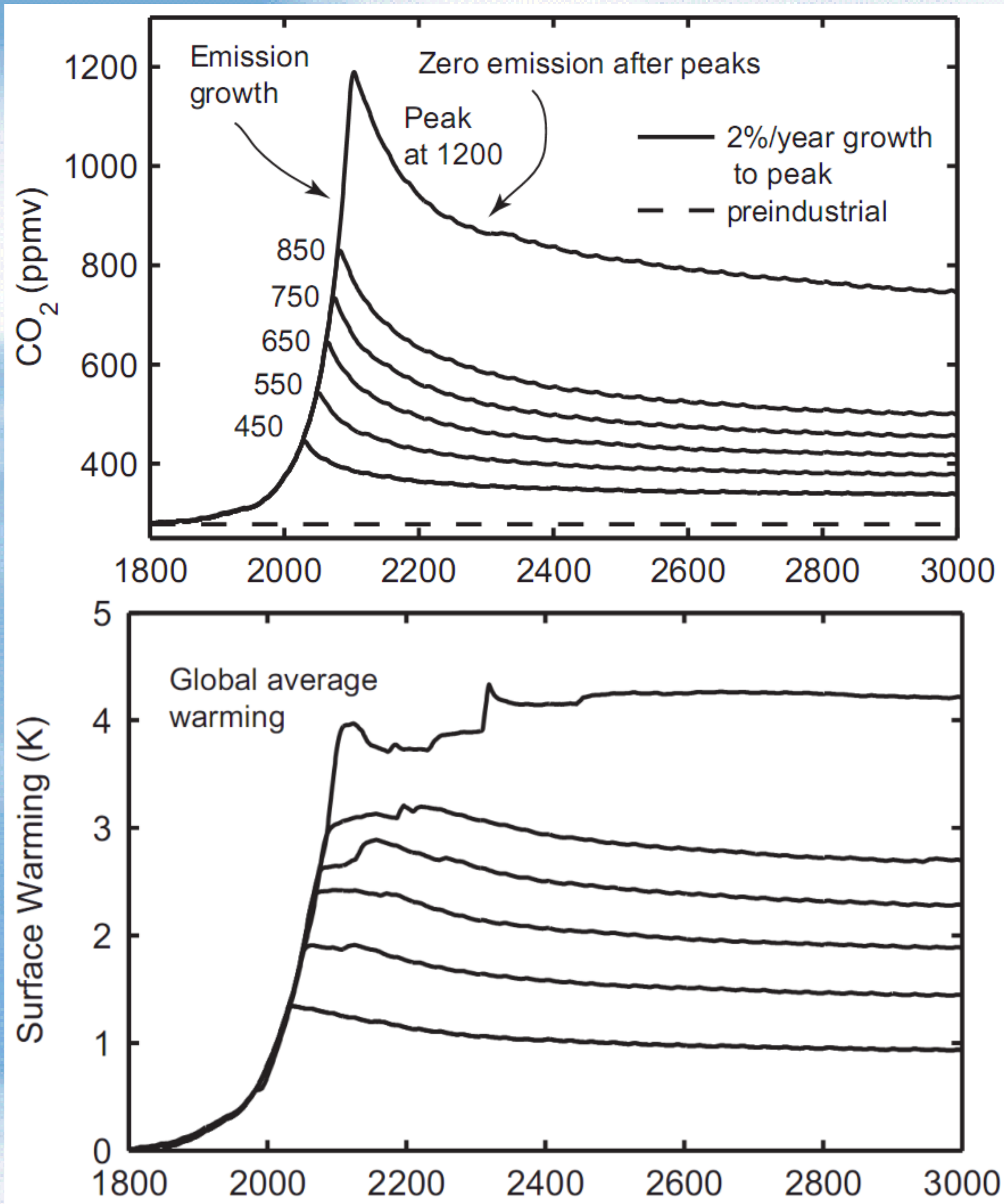
A few of the Brazilian iNDC commitments (*Reference point:* 2005):

- **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**

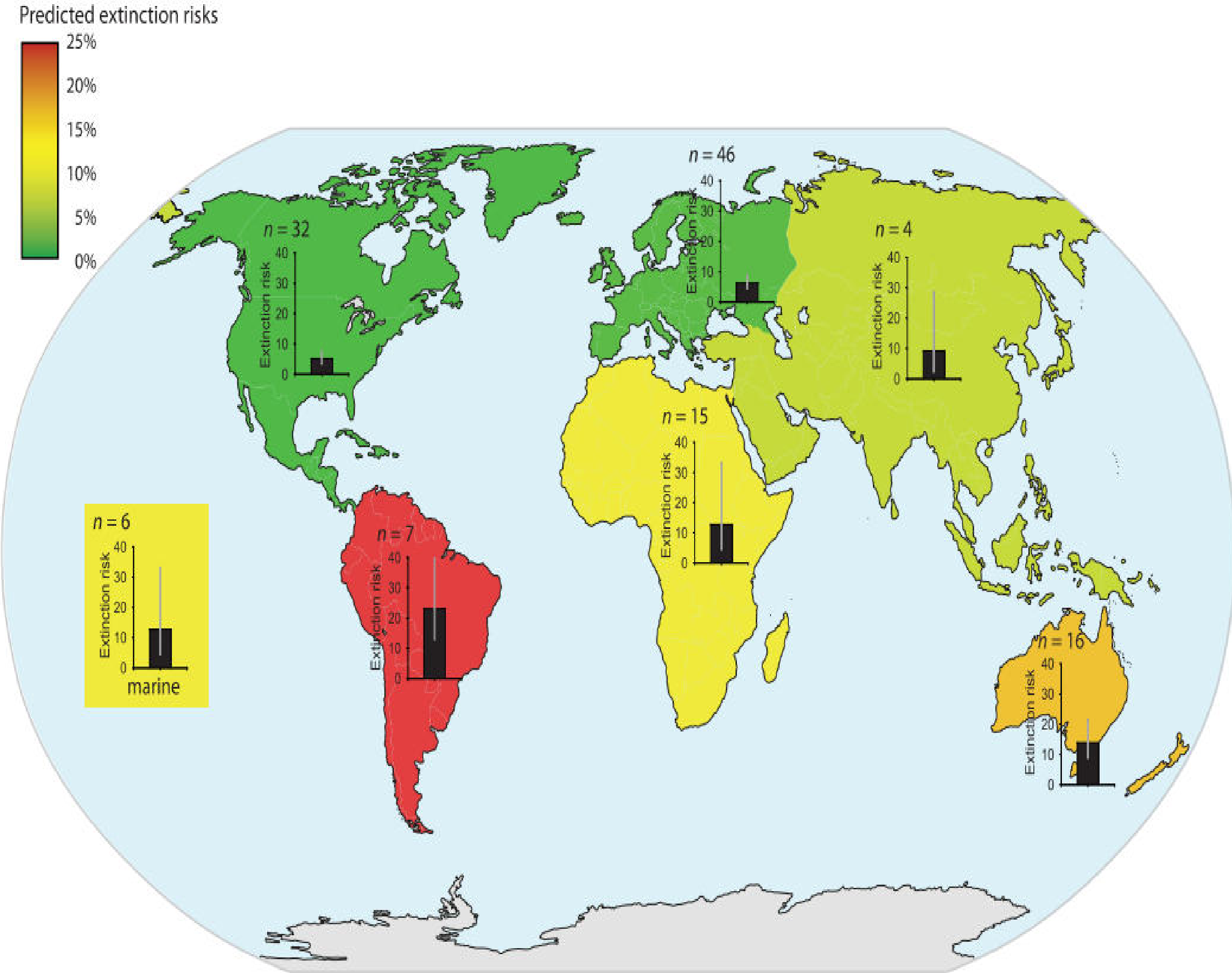
How much time the CO_2 will affect the climate?

Susan Salomon PNAS Fev 2009

Note the scale: Till year 3000 ⟶



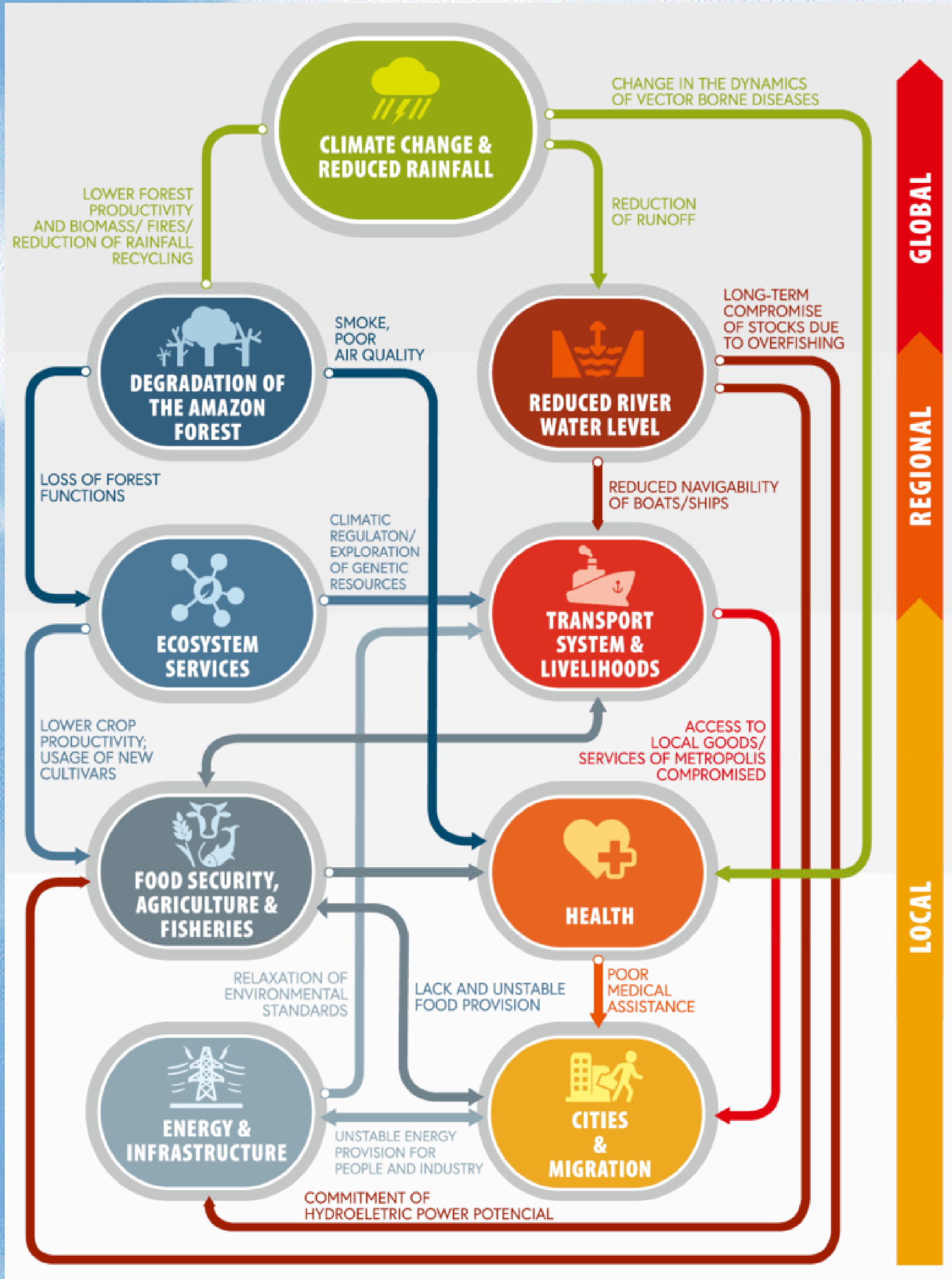
Predicted Extinction Risks of Biological Species



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

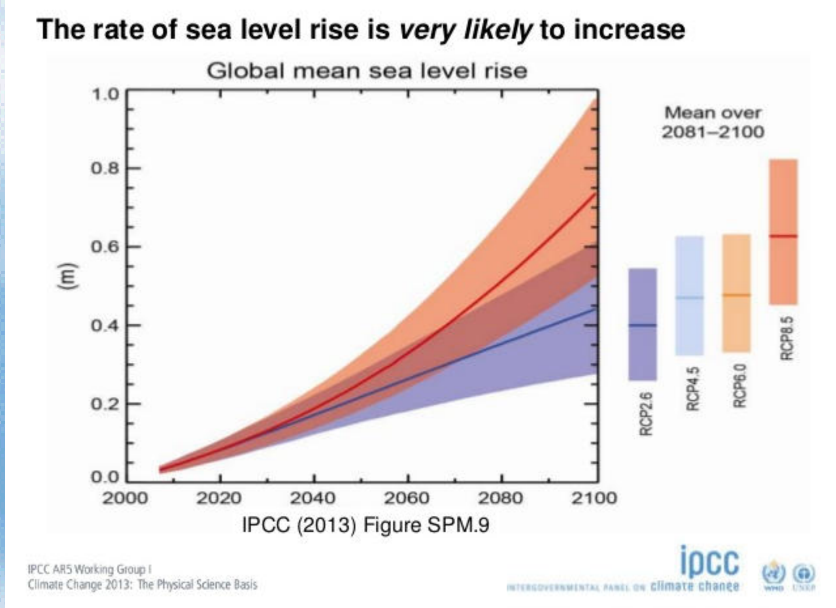
Source: Urban M.C-Nature, 2015

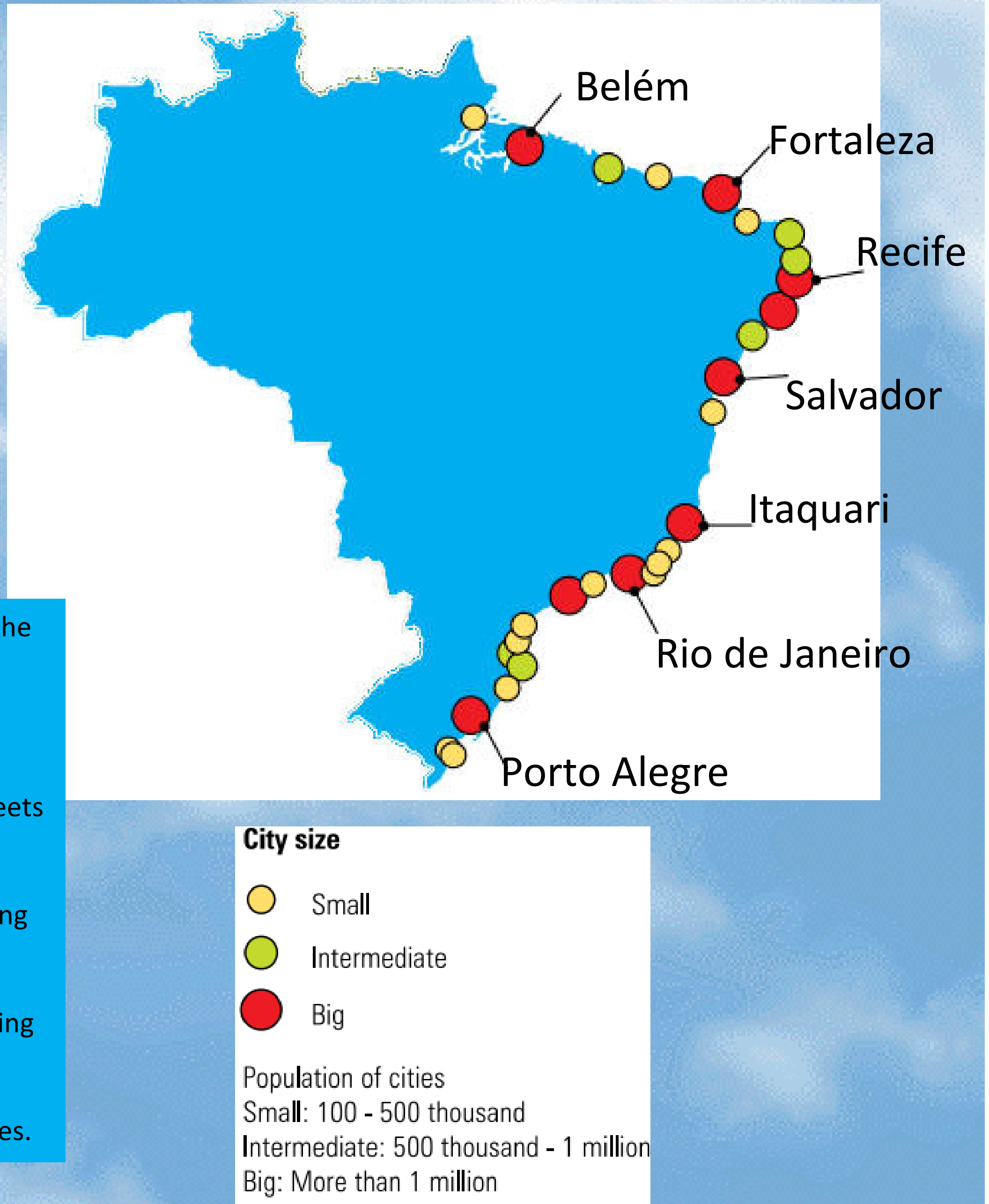
Causal chain of climate change, ecological degradation of the Amazon Forest, and their impacts on different sectors of the regions socioeconomy



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

Cidades brasileiras em risco pelo aumento do nivel do mar





In the 20th century, sea levels rose by an estimated 23 cm, and the conservative global mean projections for sea-level rise between 1990 and 2080 range from 22 cm to 100 cm.

Oceans, which have been absorbing 80% of the temperature increase attributable to global warming, are expanding as ice sheets in the North and South poles melt.

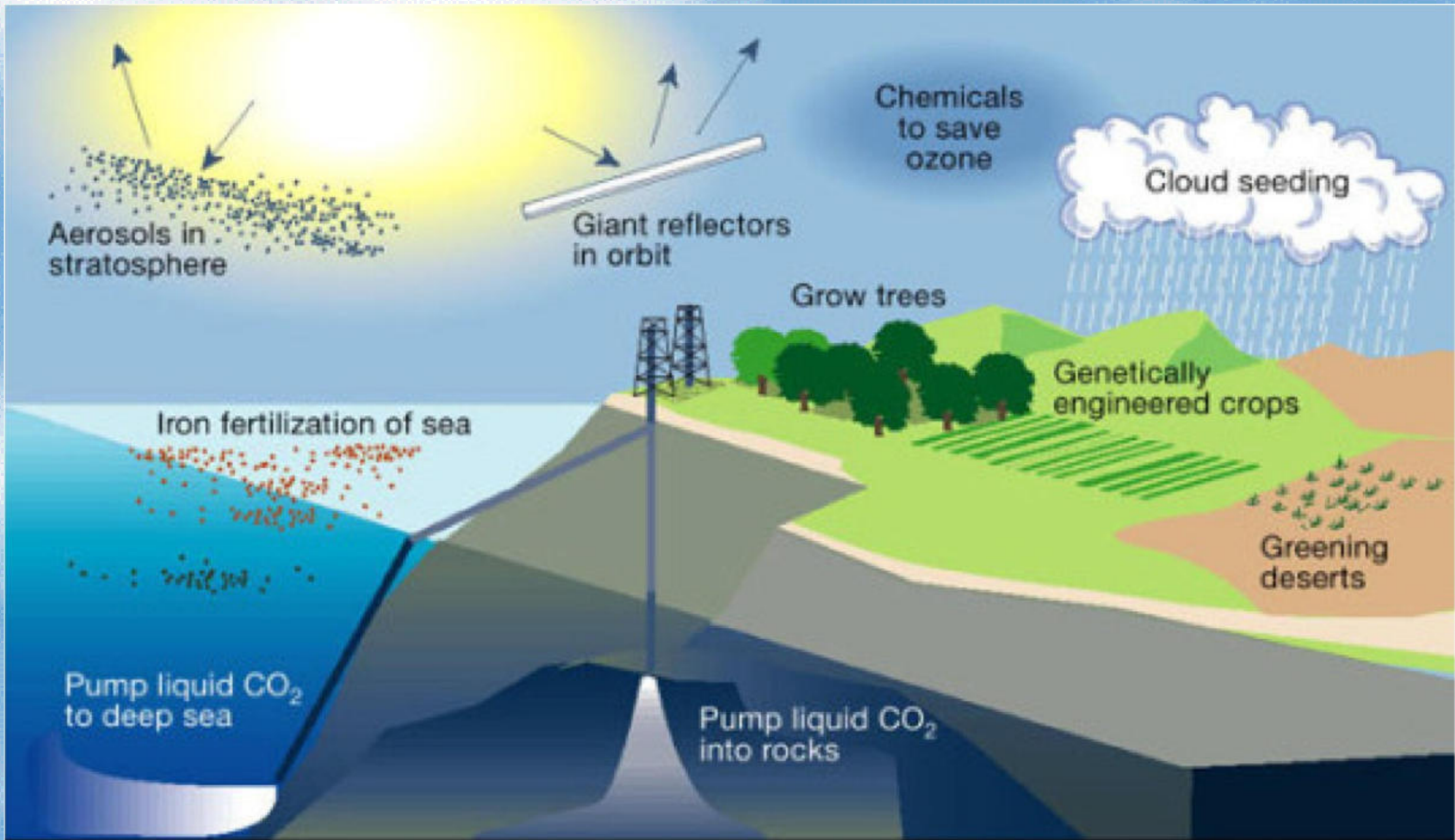
These events have led to a rise in sea levels and increased flooding in coastal cities.

The projected rise in sea levels could result in catastrophic flooding of coastal cities.

Thirteen of the world's 20 megacities are situated along coastlines.

Source: *UN-HABITAT* Global Urban Observatory 2008 (adapted)

Climate Geoengineering is defined as "deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change."

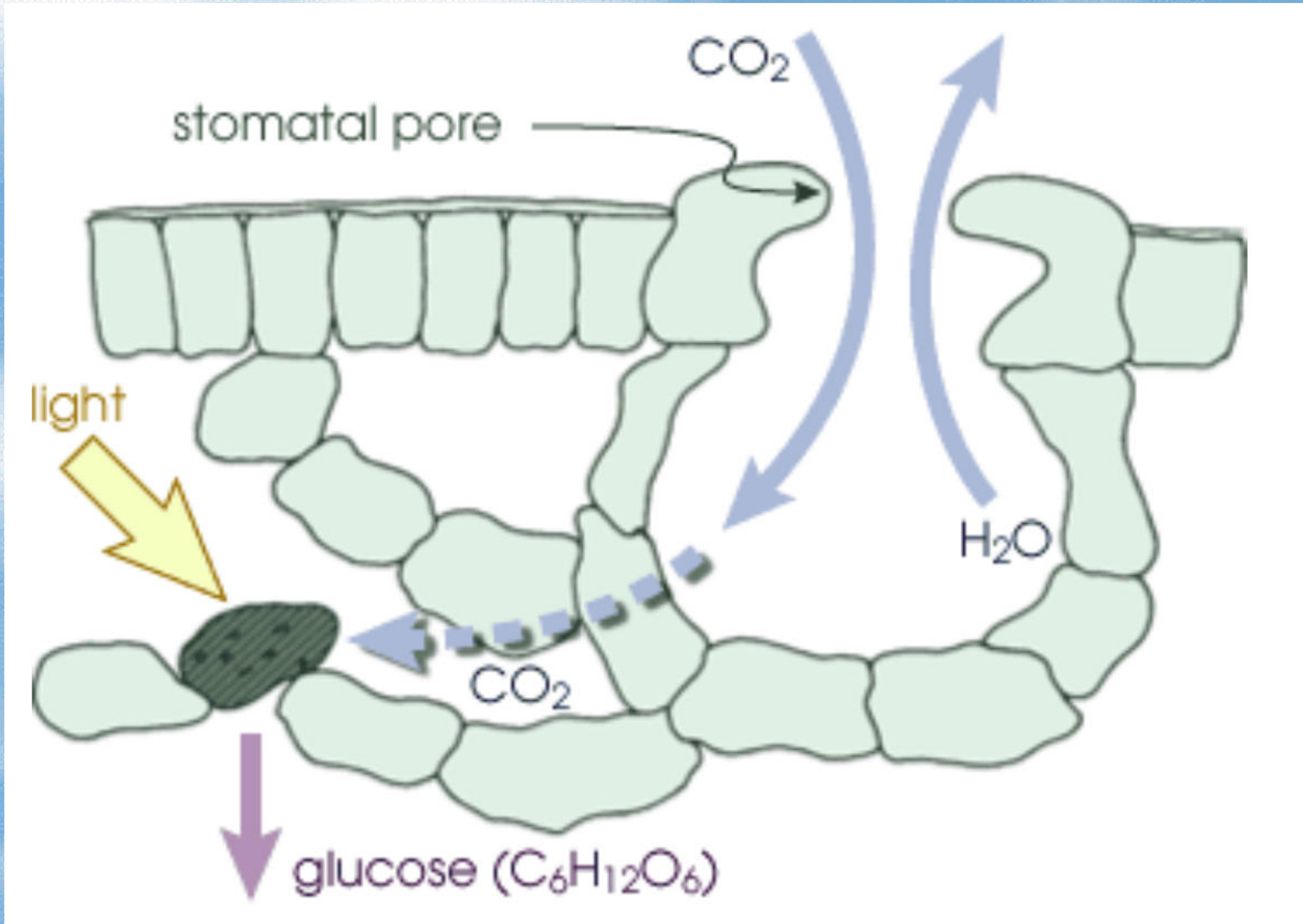


Schematic representation of various climate-engineering proposals (courtesy B. Matthews).

Shepherd, J. G. S. et al., 2009: *Geoengineering the climate: Science, governance and uncertainty*, RS Policy Document 10/09.

Fotossíntese: Radiação encontrando a Vida

Fundamento do ciclo de carbono



WORLD ECONOMIC FORUM

Perspectivas de riscos de longo prazo

Os 10 maiores riscos por probabilidade e impactos para os próximos 10 anos

Riscos para a estabilidade econômica e coesão social

Multistakeholders

Likelihood	Impact
Extreme weather	Climate action failure
Climate action failure	Weapons of mass destruction
Natural disaster	Biodiversity loss
Biodiversity loss	Extreme weather
Human-made environmental disasters	Water crises
Data fraud or theft	Information infrastructure breakdown
Cyberattacks	Natural disasters
Water crises	Cyberattacks
Global governance failure	Human-made environmental disasters
Asset bubble	Infectious diseases

Global Shapers

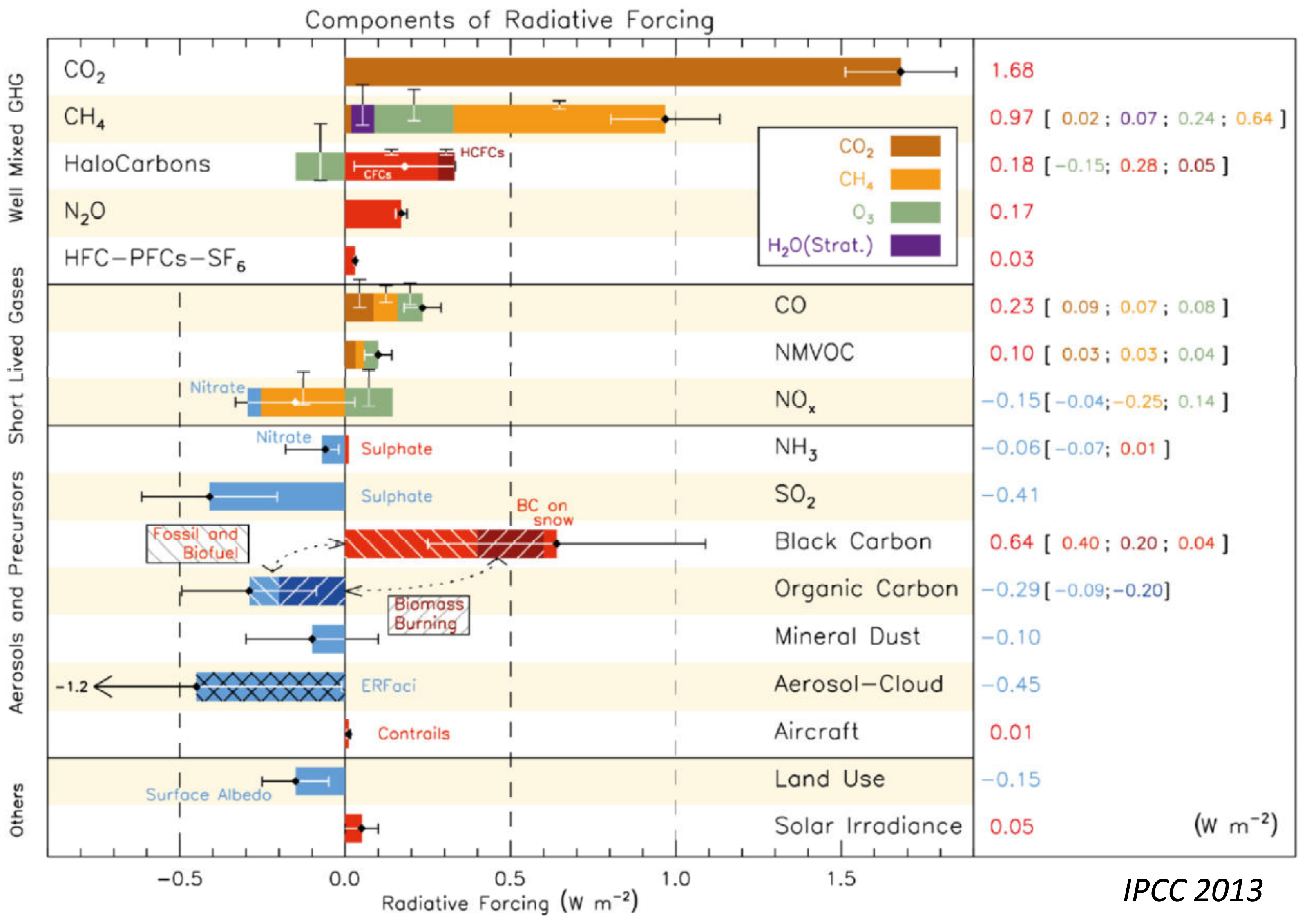
Likelihood	Impact
Extreme weather	Biodiversity loss
Biodiversity loss	Climate action failure
Climate action failure	Water crises
Natural disasters	Human-made environmental disasters
Human-made environmental disasters	Extreme weather
Water crises	Weapons of mass destruction
Data fraud or theft	Natural disasters
Involuntary migration	Food crises
Social instability	Infectious diseases
Cyberattacks	Cyberattacks

Economic | Environmental | Geopolitical | Societal | Technological

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


AMAZON ECOSYSTEMS AT A GLANCE
Maintenance of global carbon cycle
• 15% of global NPP and a key carbon sink for anthropogenic CO_2
• Stores about 120 billion ton of carbon in the biomass
Climate stabilization
• Key heat source for the atmosphere
• Annual rainfall = 2400 mm
Powerful hydrology
• 18% of fresh water flow into the global oceans
• Amazon river discharge of 220,000 m^3/s
Helps to maintain cultural and ethnic diversity
• Over 300 indigenous populations, language diversity
Biodiversity richness
• > 10% of species

Radiative forcing of climate change from 1750 to 2011



IPCC 2013

Os 17 objetivos do desenvolvimento sustentável adotados pela ONU

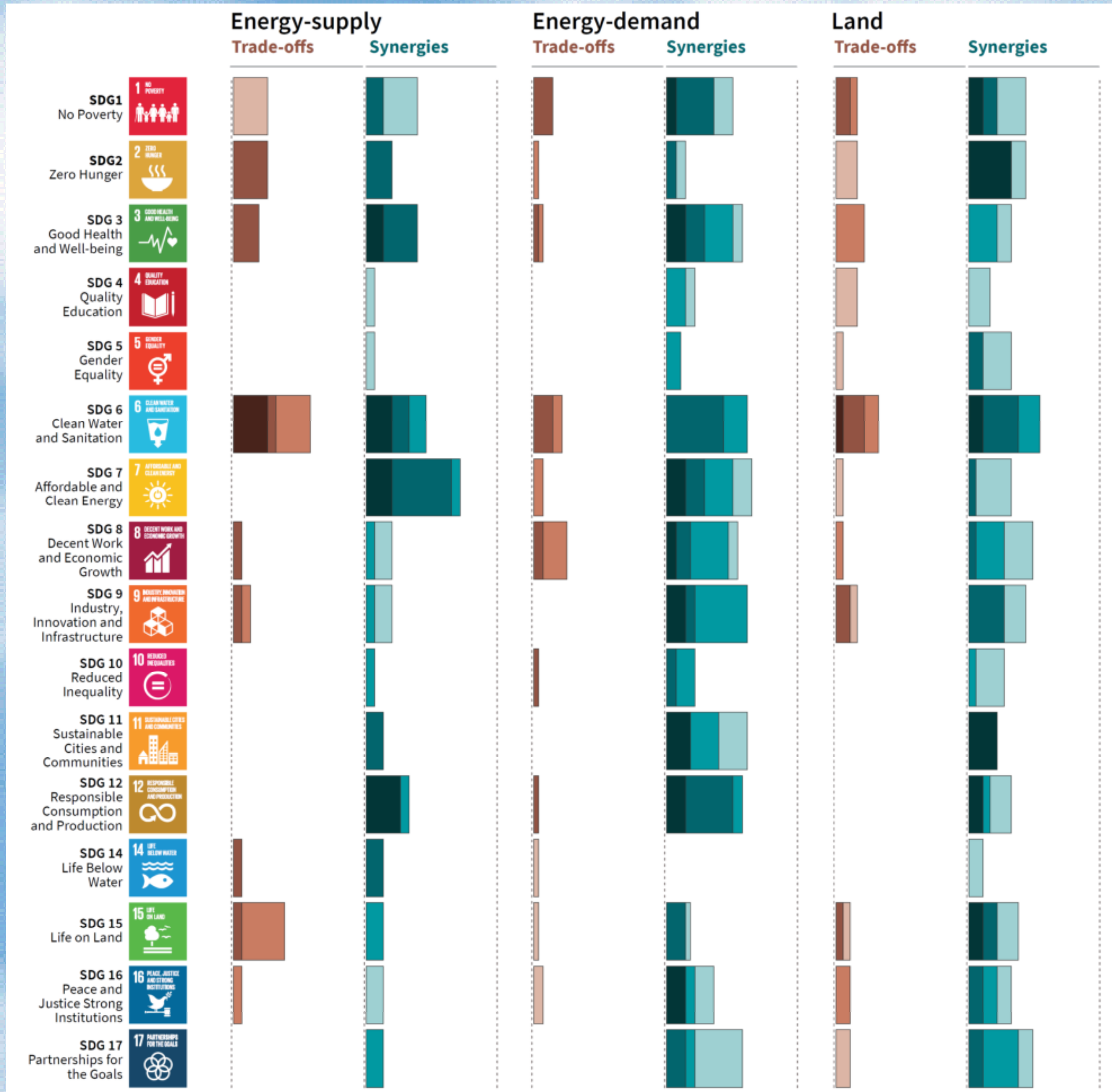
O desenvolvimento sustentável é definido como o desenvolvimento que procura satisfazer as necessidades da geração atual, sem comprometer a capacidade das futuras gerações de satisfazerem as suas próprias necessidades.

OBJETIVOS DE DESENVOLVIMENTO SUSTENTÁVEL
17 OBJETIVOS PARA TRANSFORMAR NOSSO MUNDO

SUSTAINABLE DEVELOPMENT GOALS

UN 17 goals to transform our world

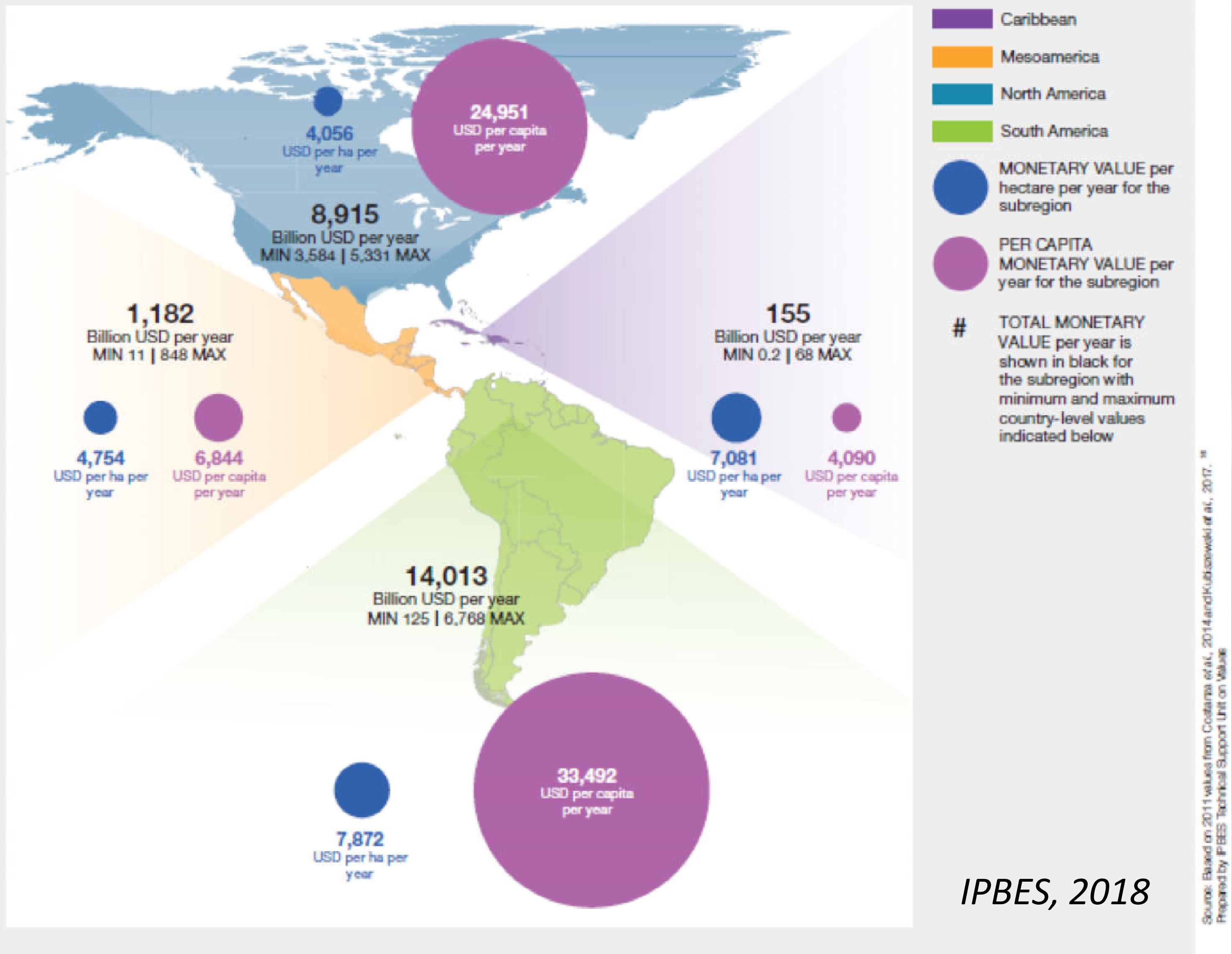
Mitigation options and sustainable development using SDGs



Potential positive effects (synergies)
Negative effects (trade-offs)

IPCC SR1.5, 2018

Valor econômico estimado dos serviços ecossistêmicos nas Américas



IPBES, 2018

Agriculture, food production, and deforestation are major drivers of climate change.

The food system as a whole, which also includes food production and processing, transport, retail, consumption, loss and waste, **is currently responsible for up to a third of our global greenhouse gas emissions**.

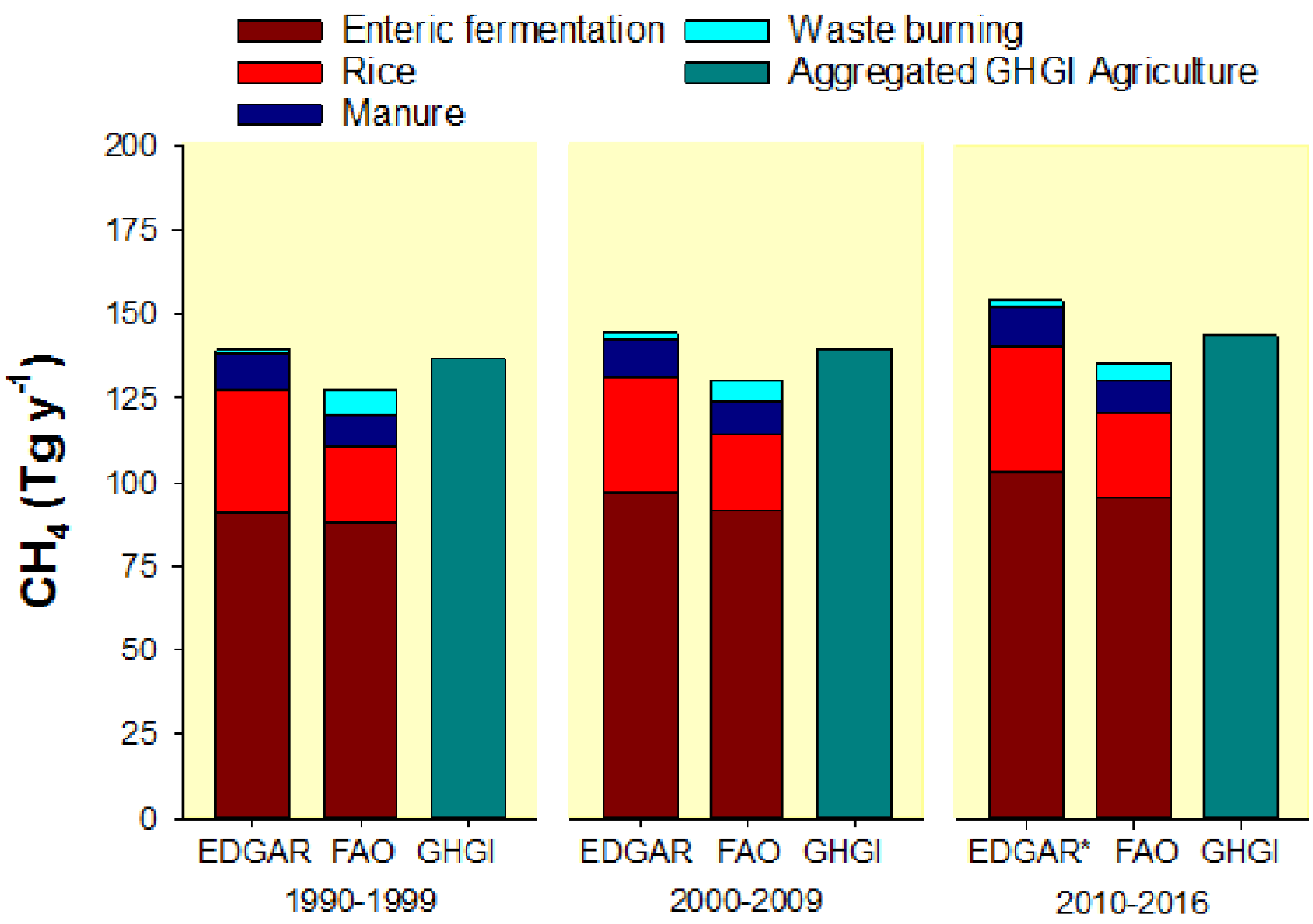
Deforestation, peatland burning and wood harvest are directly contributing around 13% of CO_2 emissions

Land accounts for **61% of anthropogenic CH_4** emissions (GWP=28).

50% of the nitrogen applied to agricultural land **not taken up** by the crop, resulting in N_20 emissions (GWP=265).

INTERGOVERNMENTAL PANEL ON climate change

Agriculture CH_4 emissions 1990-2016



Let's eat less meat? About 1 billion people today do not have access to high protein diets…

IPCC SRCCL 2019

As seis grandes transformações necessárias para o mundo em 2050

Energia

Decarbonização, eficiência, acesso à energia

Consumo e Produção Sustentáveis

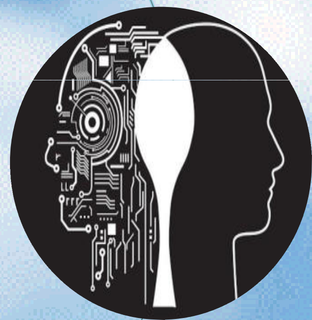
Uso de recursos, economia circular, suficiência, poluição

Alimentos, Usos da Terra & Biosfera

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

Objetivos de Desenvolvimento Sustentável:

- Prosperidade
- Inclusão social
- Sustentabilidade
- Paz social

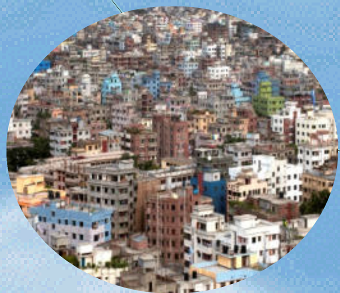


Revolução Digital

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

Cidades

Moradia, mobilidade, Infraestrutura sustentável, água, poluição

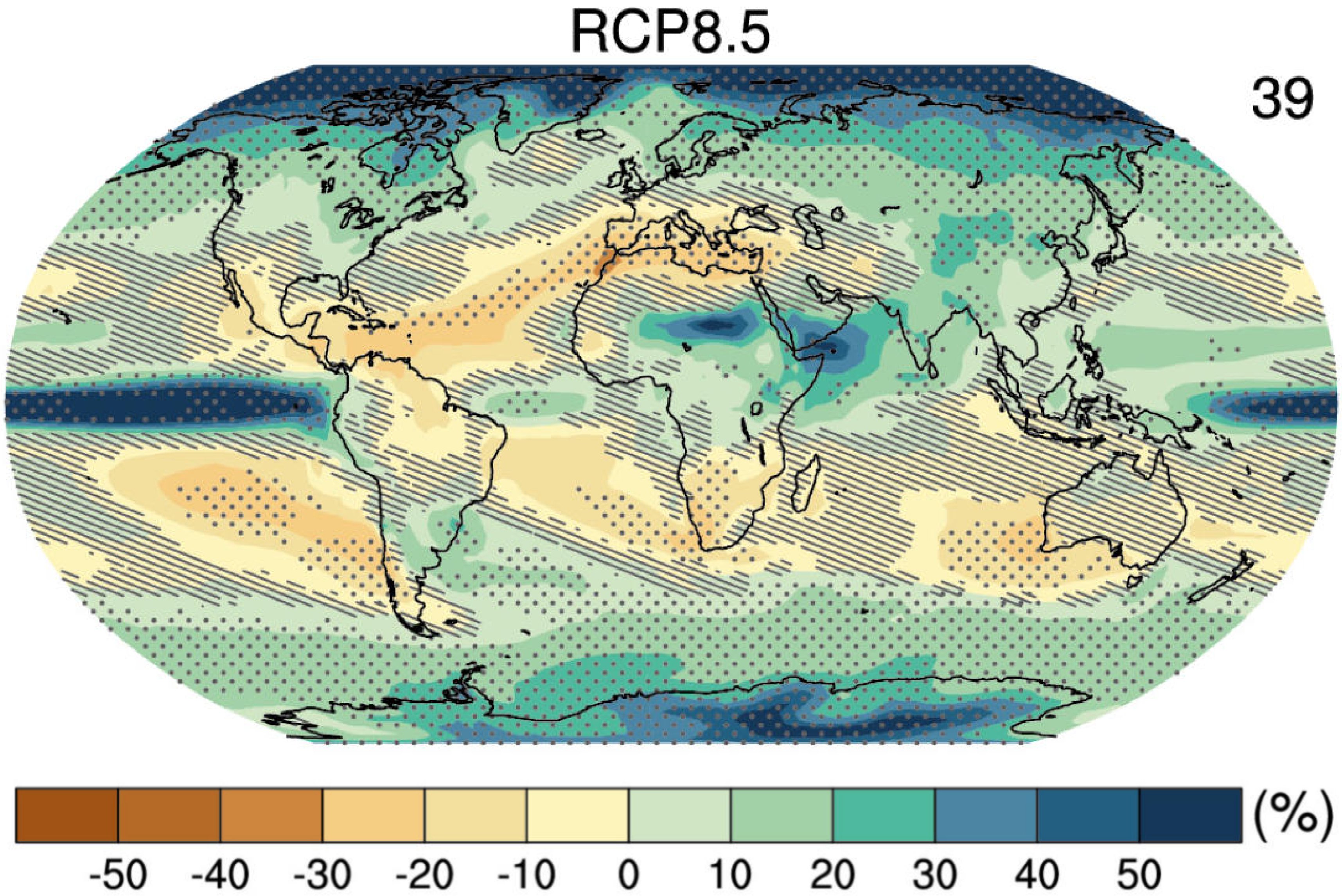


Capacitação Humana & Demografia

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

Adaptado de The World in 2050

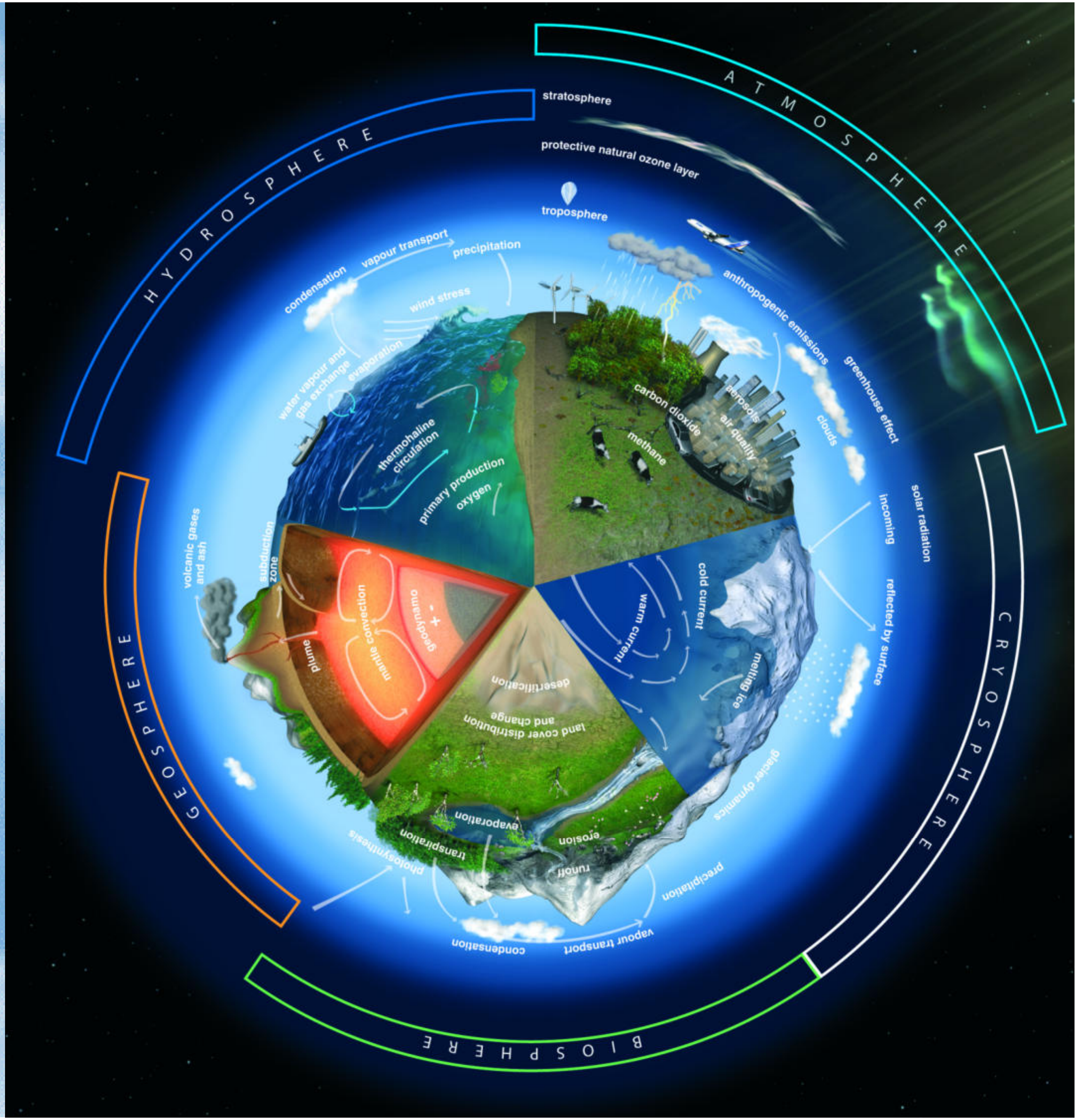
Annual mean precipitation change 2081-2100 versus 1986-2005



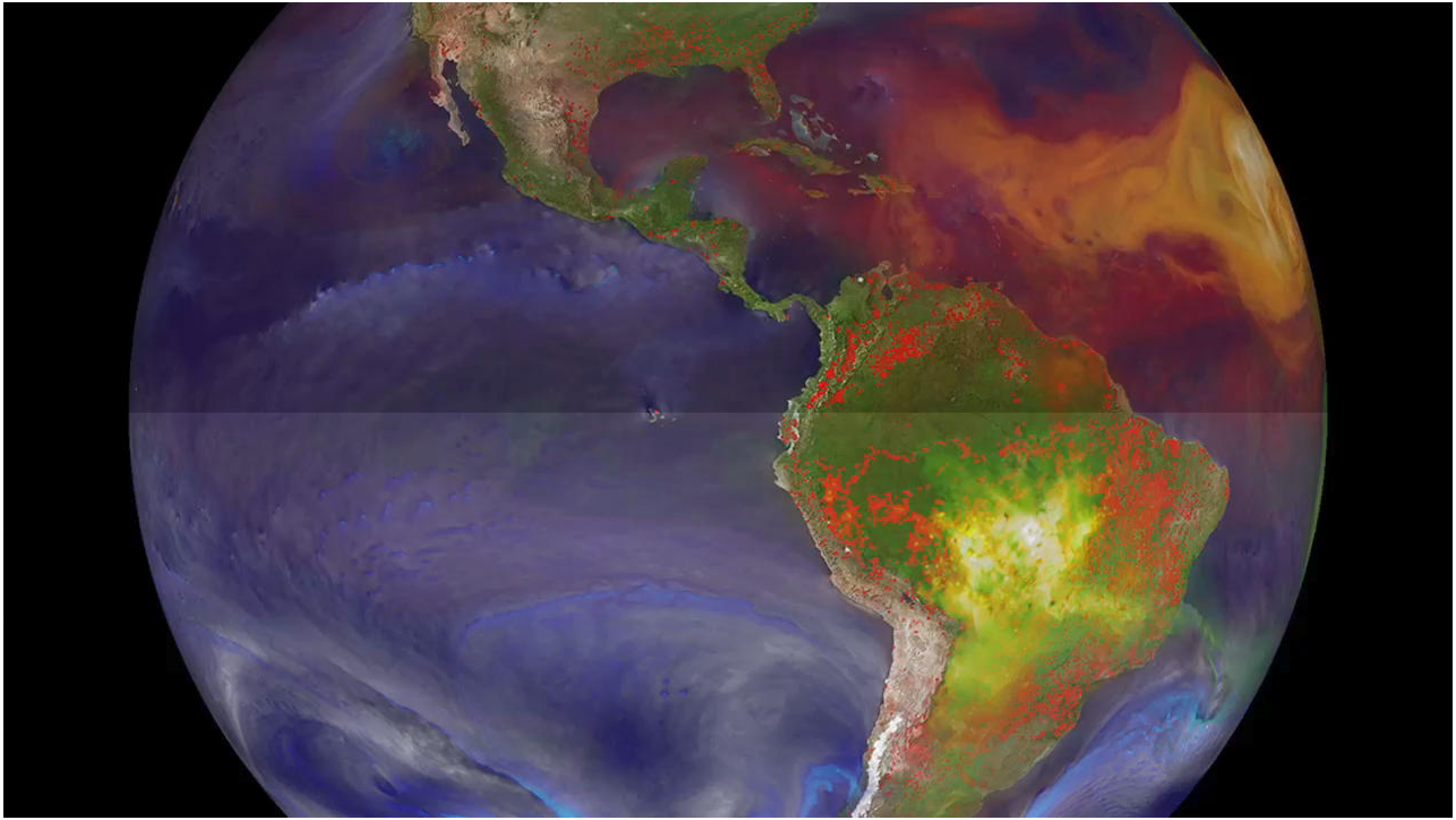
Nosso planeta em mudança, nos compartimentos:

Atmosfera
Criosfera
Biosfera
Geosfera
Hidrosfera

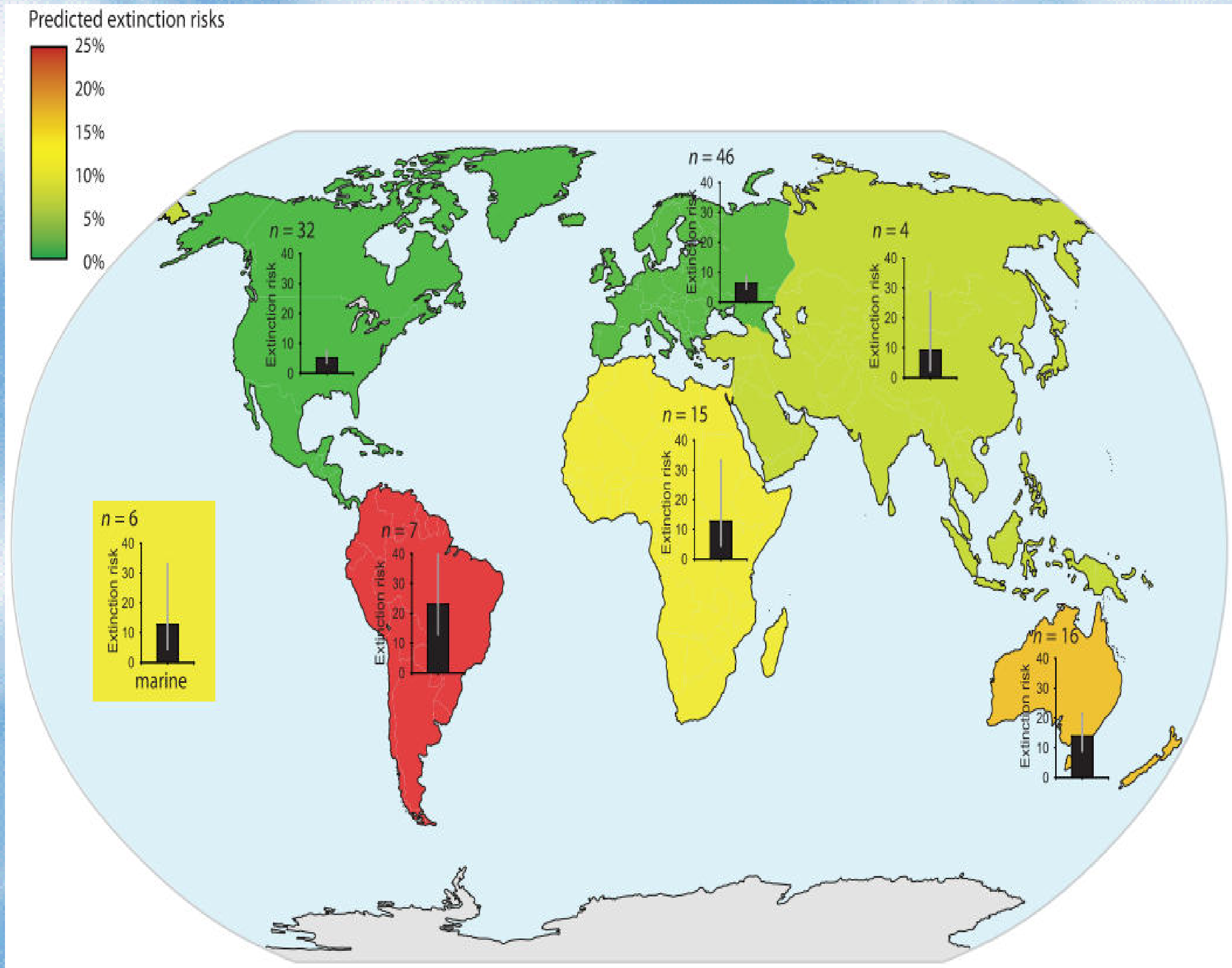
Os limites disciplinares tambem não existem



Partículas de aerossóis na atmosfera



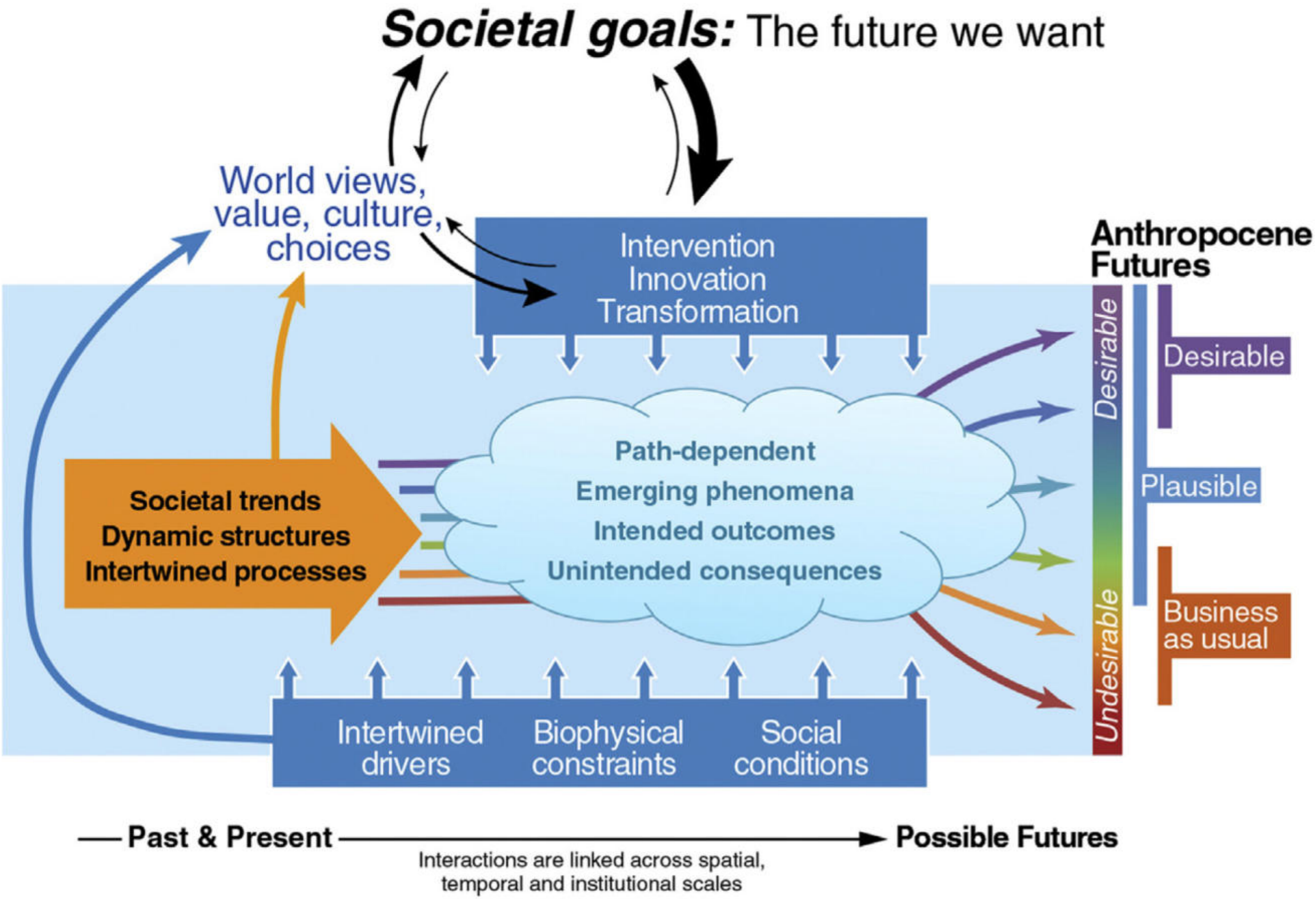
Risco de perdas de espécies biológicas



Os maiores riscos: América do Sul, Austrália (14 a 23%)

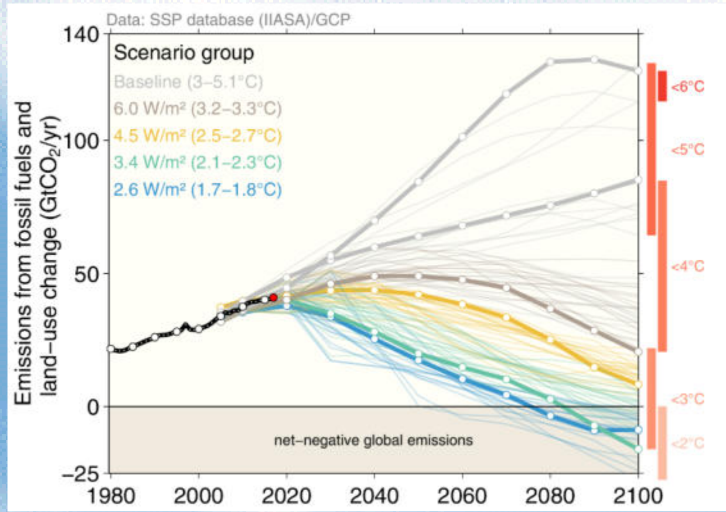
Fonte: Urban M.C-Nature, 2015

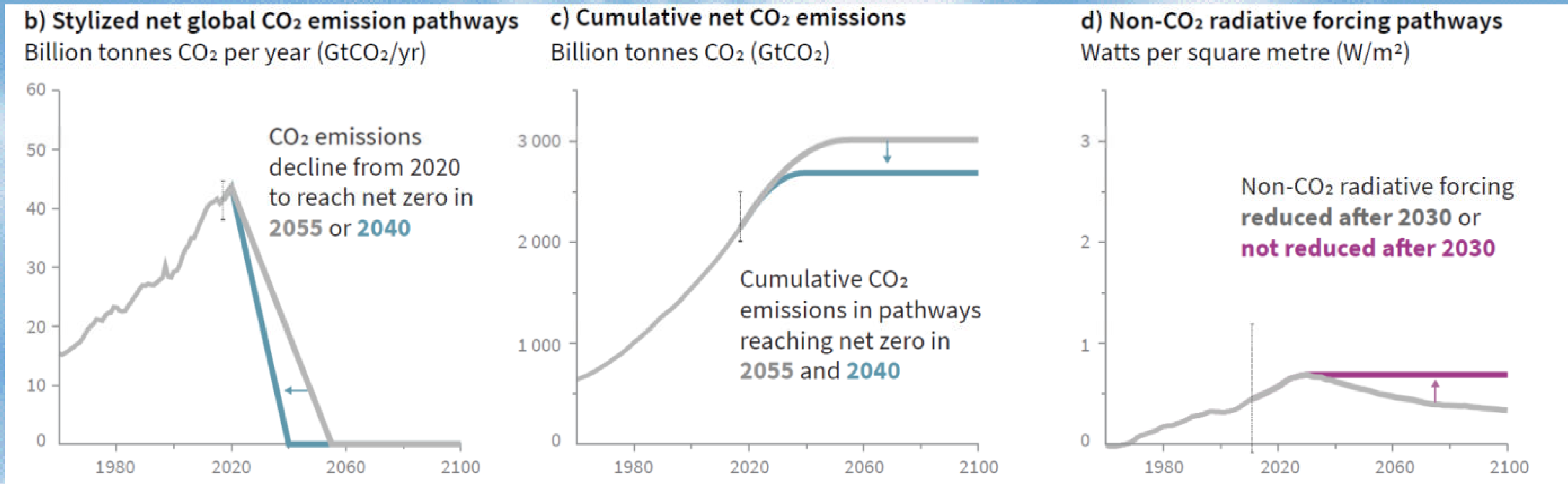
Qual o futuro que queremos? O futuro do Antropoceno



Global Environmental Change 39 (2016) 351–362

IPCC: Emissions reductions necessary to limit warming to 1.5 degrees



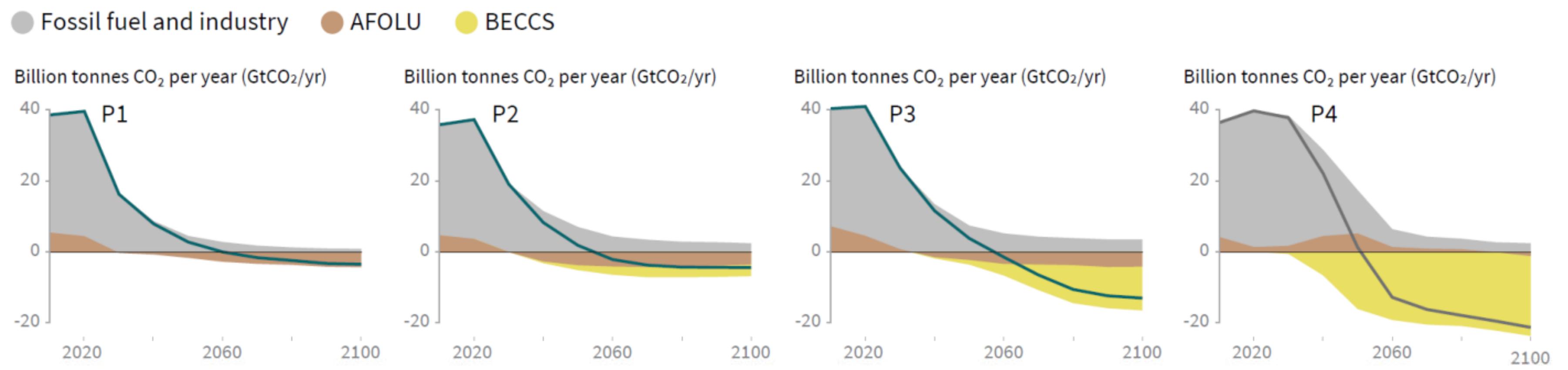


Faster immediate CO2 emission reductions limit cumulative CO2 emissions shown in panel **(c)**.

Reductions in BC, methane, ozone precursors

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

Net emissions for 4 possible scenarios



P1: A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

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

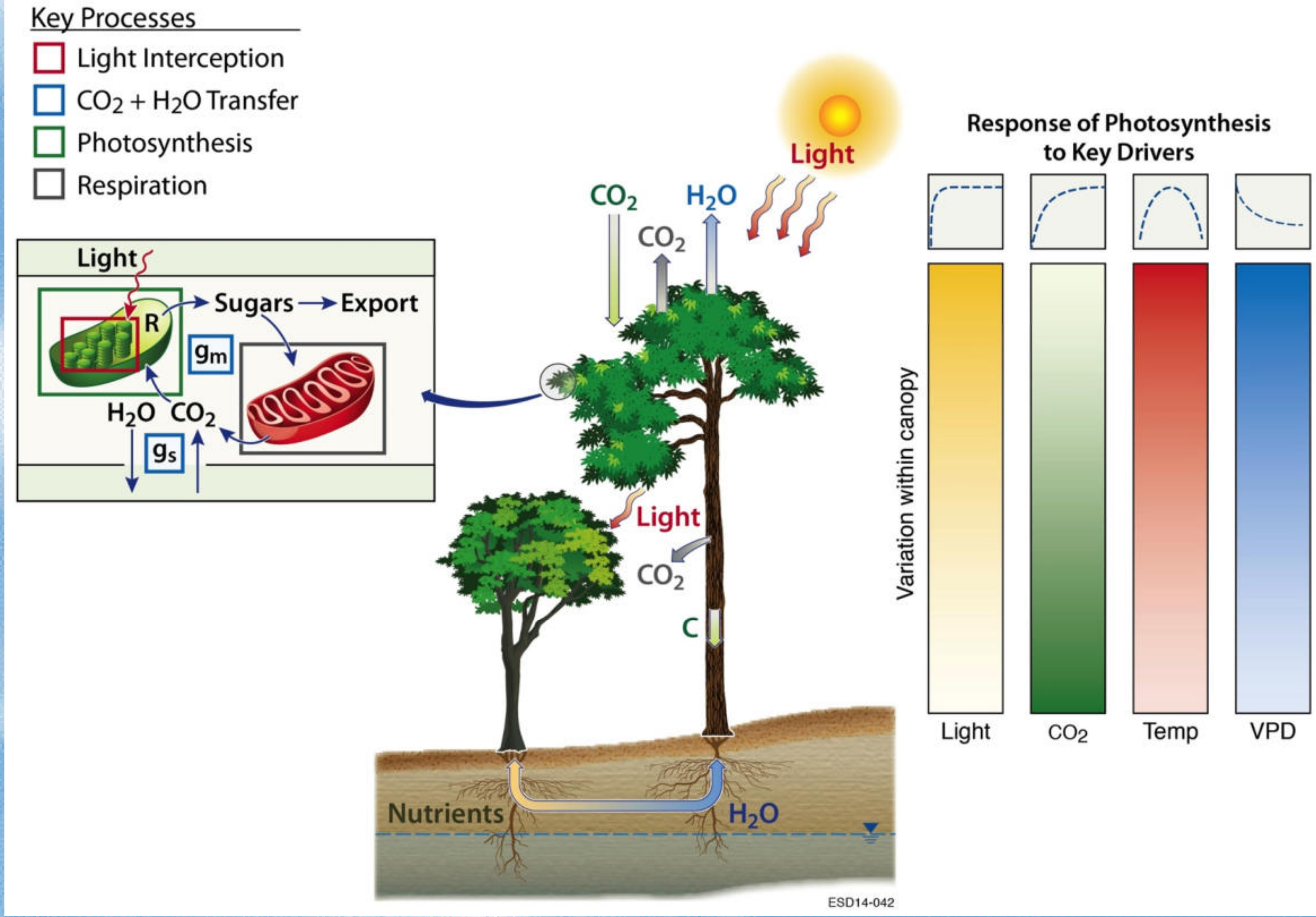
AFOLU - Agriculture, Forestry and Other Land Use

CDR - Carbon Dioxide Removal

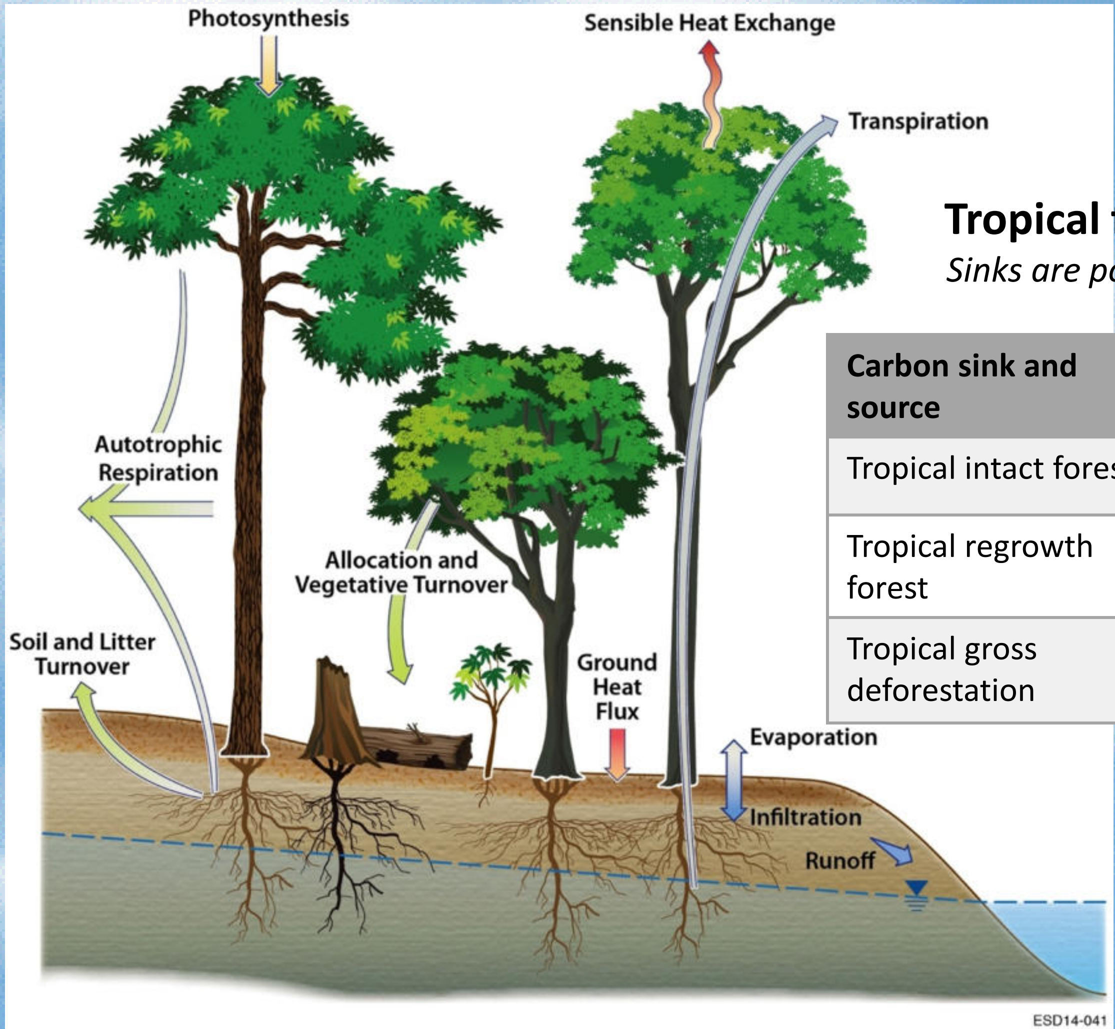
BECCS - Bioenergy with Carbon Capture and Storage

Photosynthesis: GPP and plant respiration key drivers

Models require better representation of the diversity of plant traits & trade-offs dictating GPP and respiration, and their responses to environmental drivers.



Tropical Forests and the Global Carbon Cycle



Tropical forest carbon budgets (Pg C yr^{-1})

Sinks are positive values; sources are negative values

(Pan et al., 2011)

Carbon sink and source	1990-1999	2000-2007	1990-2007
Tropical intact forest	1.33 ± 0.35	1.02 ± 0.47	1.19 ± 0.41
Tropical regrowth forest	1.57 ± 0.50	1.72 ± 0.54	1.64 ± 0.52
Tropical gross deforestation	−3.03 ± 0.49	−2.82 ± 0.45	−2.94 ± 0.47*

*-0.9 ± 0.5 Pg C yr^{-1} globally for 2005-2014

2014 fossil fuel emissions 9.8 ± 0.5 Pg C yr^{-1}

(Global Carbon Project 2017)

The world's tropical forests are a net carbon source of **425.2 ± 92.0 Tg C yr–1**. This net release of carbon consists of losses of 861.7 ± 80.2 Tg C yr–1 and gains of 436.5 ± 31.0 Tg C yr–1. Gains result from forest growth; losses result from deforestation and from reductions in carbon density within standing forests (degradation/disturbance), with the latter accounting for 68.9% of overall losses. (Science May 2018)

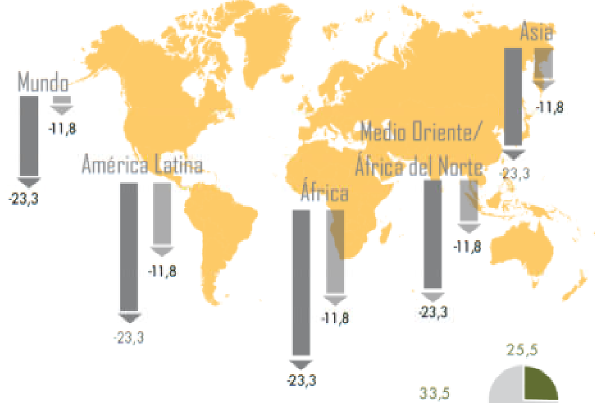
IMPACTOS ECONÓMICOS DEL CAMBIO CLIMÁTICO SOBRE EL SECTOR AGRÍCOLA

El sector agrícola tiene una importancia estratégica en América Latina y el Caribe

América Latina: indicadores seleccionados del sector agrícola, alrededor de 2012[a]
(En porcentajes)

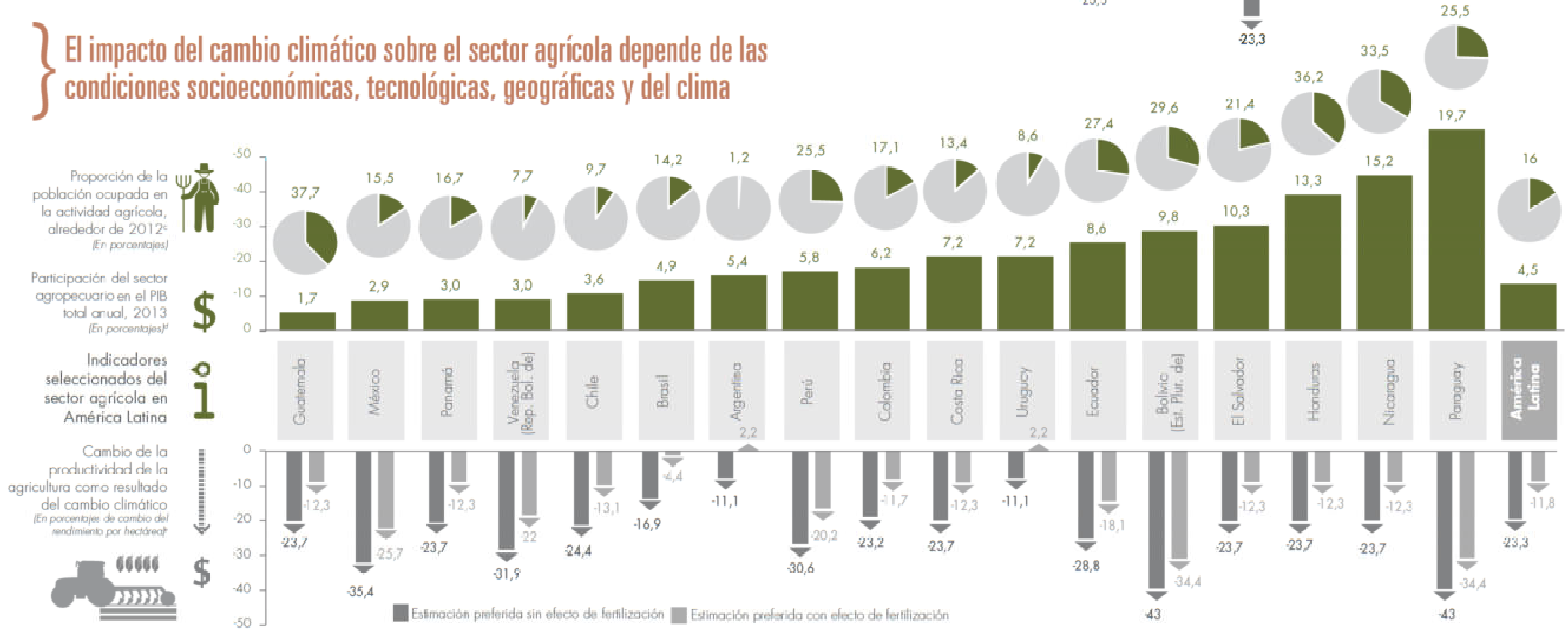
- 5% del PIB
- 16% de la población ocupada
- 23% de las exportaciones regionales
- 22% de la población vive en zonas rurales

El aumento de temperatura, el cambio de los patrones de precipitación y los eventos climáticos extremos ponen en riesgo al sector agrícola



Cambio de la productividad de la agricultura como resultado del cambio climático[b]
(En porcentajes de cambio del rendimiento por hectárea)

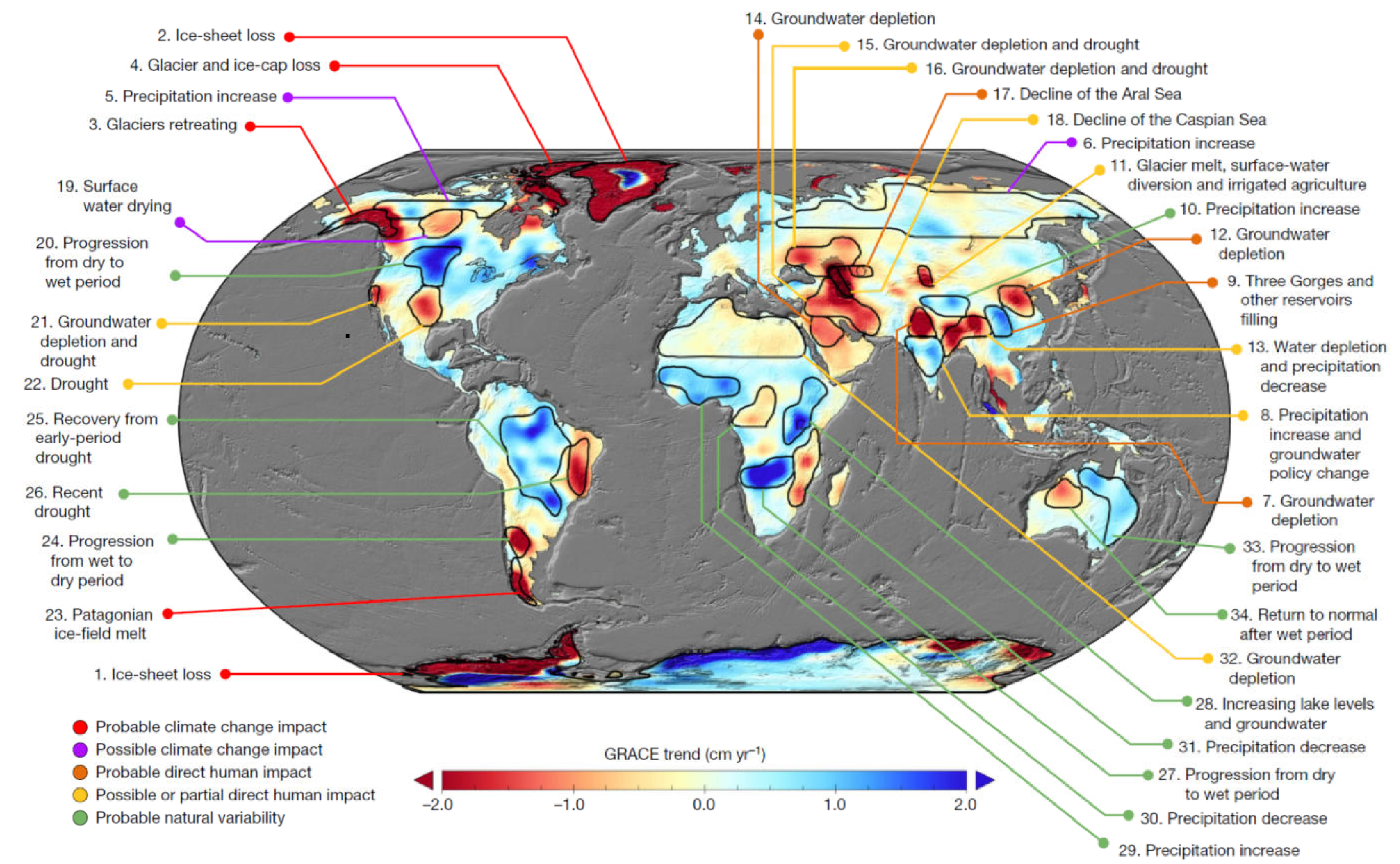
El impacto del cambio climático sobre el sector agrícola depende de las condiciones socioeconómicas, tecnológicas, geográficas y del clima



▸ [a] CEPAL, CEPALSTAT. ▸ [b] Cline, W. (2008), Global warming and agriculture, en Finance & Development. ▸ [c] CEPAL, cEPALSTAT sobre la base de encuestas de hogares de los países. ▸ [d] CEPAL, CEPALSTAT sobre la base de datos oficiales de los países. +Incluye agricultura, ganadería, caza, silvicultura y pesca. El dato de Argentina proviene del Banco Mundial. ▸ [e] Cline, W. (2007), Global warming and agriculture: impact estimates by country, Peterson Institute. +El Impacto sobre la agricultura del cambio climático se obtuvo a partir de una función lineal de la estimación preferida del impacto en 2080 incluido en el Cline (2007). El impacto para América Latina y el Caribe es el promedio simple. Se supuso que el impacto para Paraguay es el reportado bajo de rubro de "Otros Sudamérica", el impacto de Uruguay es el mismo que el de Argentina. ▸ [f] Valores obtenidos del Banco Mundial. ▸ Algunos elementos gráficos incluidos en la lámina han sido diseñados por Freepik.com.

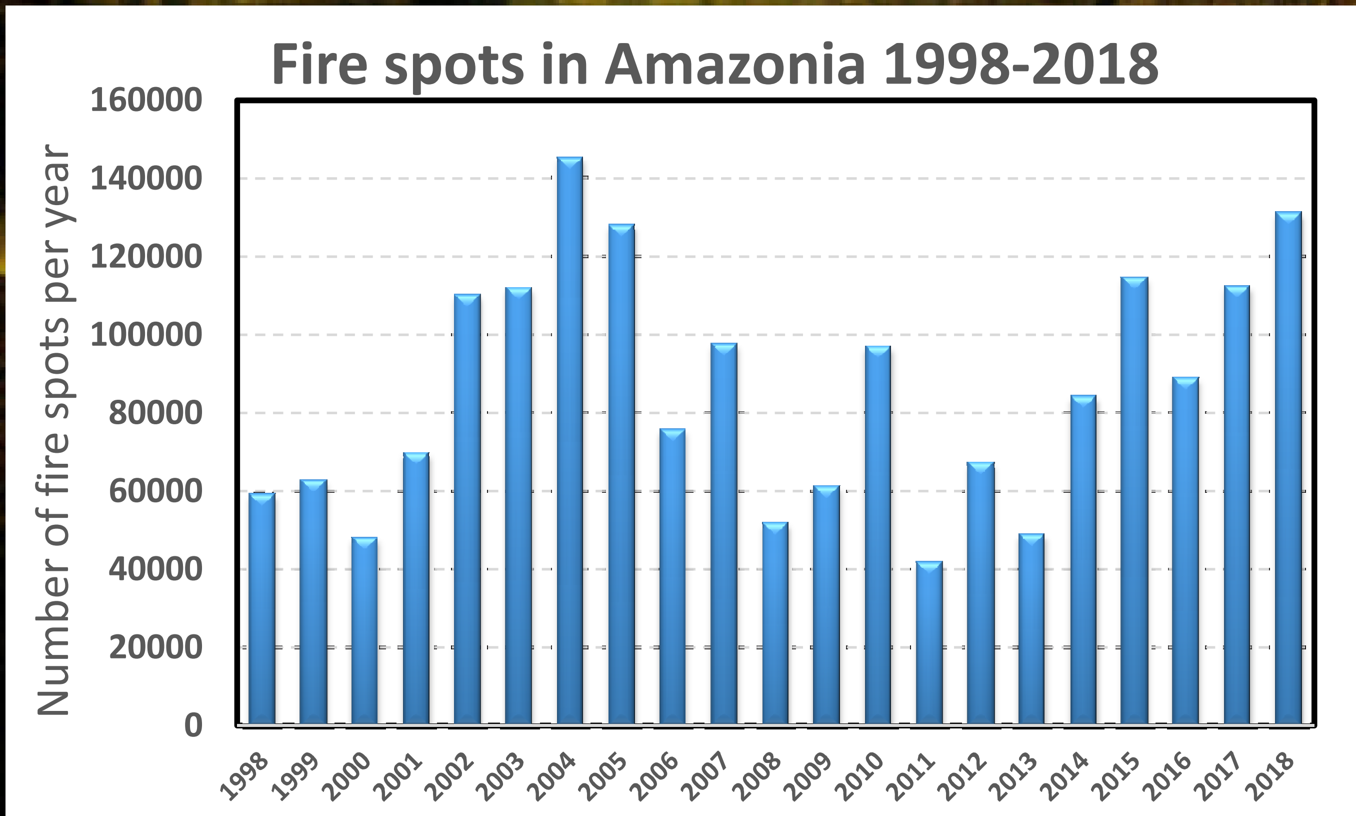
Fuente: Comisión Económica para América Latina y el Caribe (CEPAL).

The changing terrestrial water cycle (in cm per year) GRACE satellite from 2002 to 2016



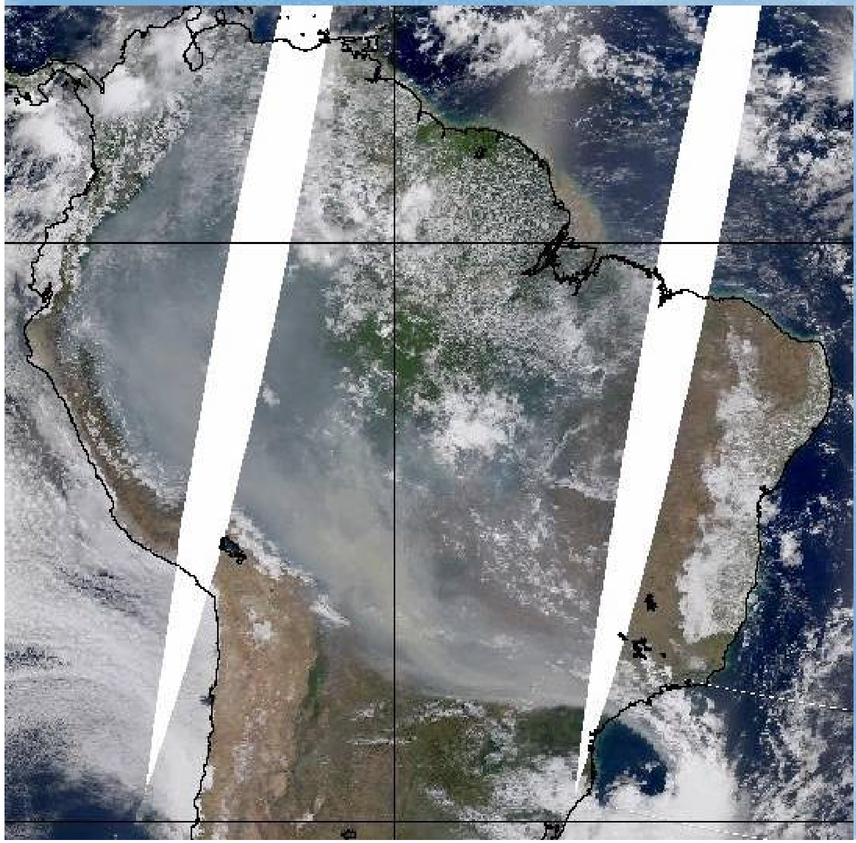
Terrestrial water cycle: sum of groundwater, soil moisture, surface waters, snow and ice

Biomass Burning...



Large scale aerosol distribution in Amazonia

- Severe health effects on the Amazonian population (about 20 million people)
- Climatic effects, with strong effects on cloud physics and radiation balance.
- Changes in carbon uptake and ecosystem functioning



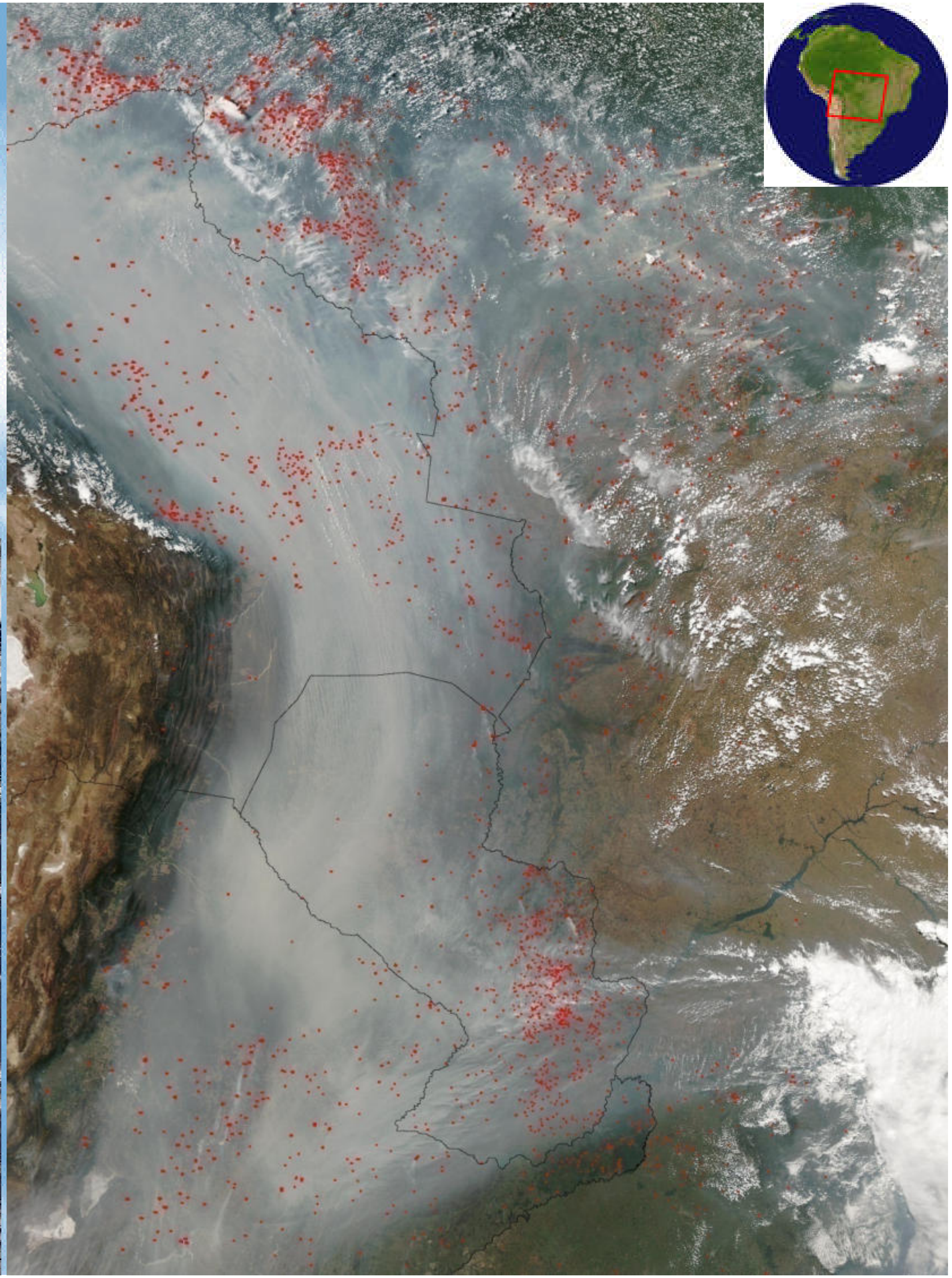


Table 21.1: Percentage of countries by region projected to achieve selected SDG targets in 2030

	Europe and Russian Federation	Latin America and Caribbean	Middle East and North Africa	Non-OECD Asia Pacific	North America	OECD Asia Pacific	South Asia	Sub-Saharan Africa	World
Extreme poverty	100	68	85	70	100	100	79	21	67
Hunger	95	32	70	26	100	100	43	10	48
Underweight children	82	48	30	26	100	100	14	0	37
Child mortality	98	90	90	74	100	50	71	6	67
Primary school completion	100	94	85	78	100	100	86	33	77
Lower secondary school	89	35	40	48	100	100	50	4	45
Access to safe water	98	94	95	70	100	100	93	17	72
Improved sanitation	80	29	65	43	100	100	43	4	44
Access to electricity	100	68	90	48	100	100	71	2	60

Source: Moyer and Hedden (2018).

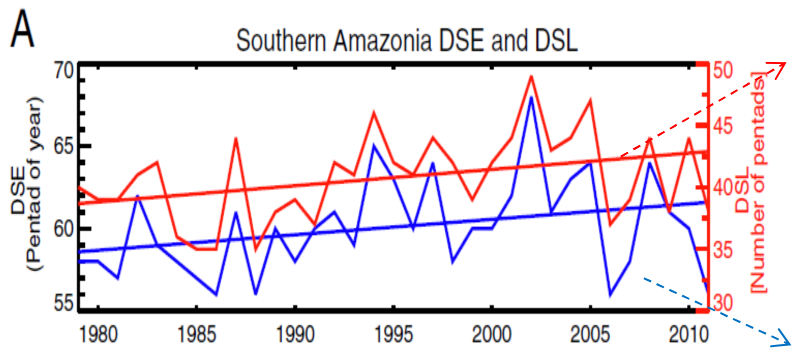
Strong linkages between climate and achievement of the Sustainable Development Goals

There are synergies and trade-offs in terms of climate costs on implementing the Sustainable Development Goals

Direct linkages are shown with bold arrows, indirect linkages with light arrows.

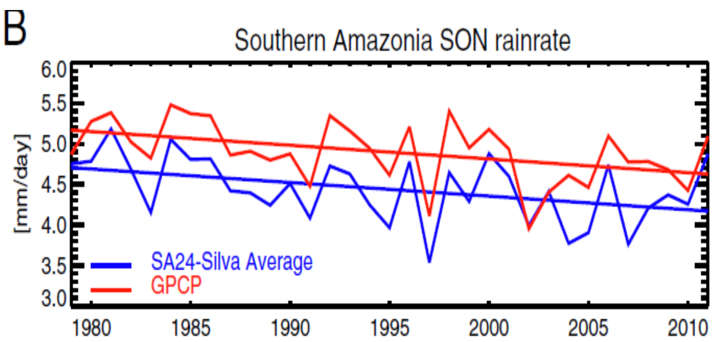
A Ciência é muito sólida nesta área, com centenas de relatórios de agências internacionais e milhares de artigos científicos todo ano

Dry season length is increasing in Amazonia



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

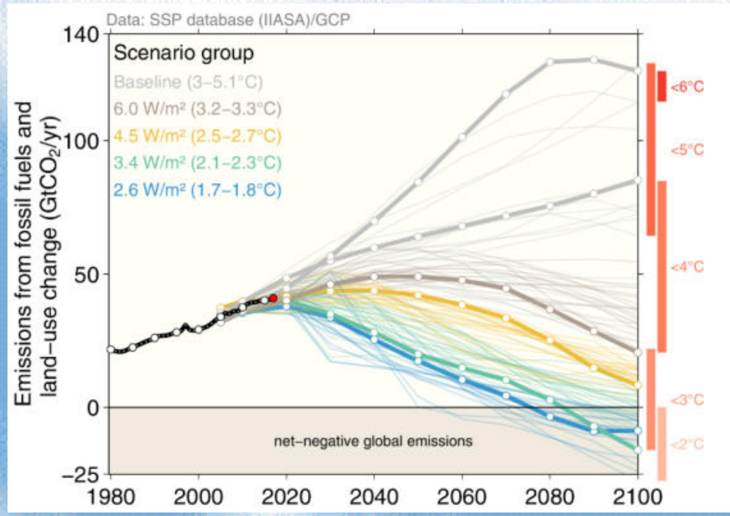
Annual time series of **dry season** END (DSE)

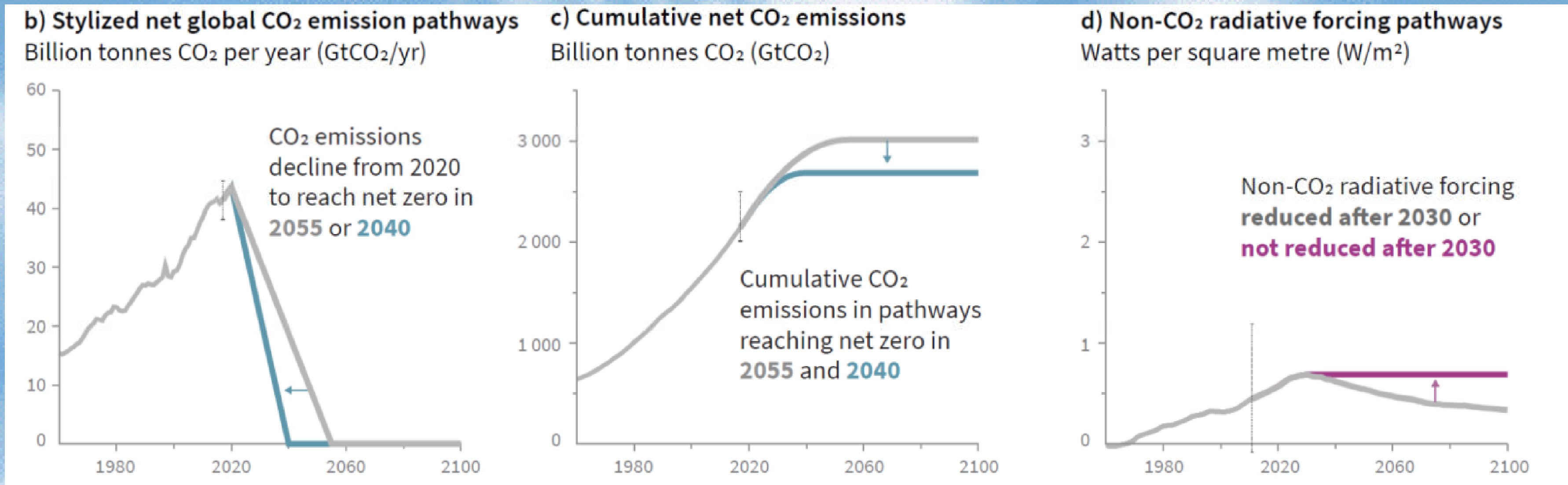


Dry season length has increased by **6.5±2.5** days/decade;

Fu et al. 2013 (PNAS)

IPCC: Emissions reductions necessary to limit warming to 1.5 degrees



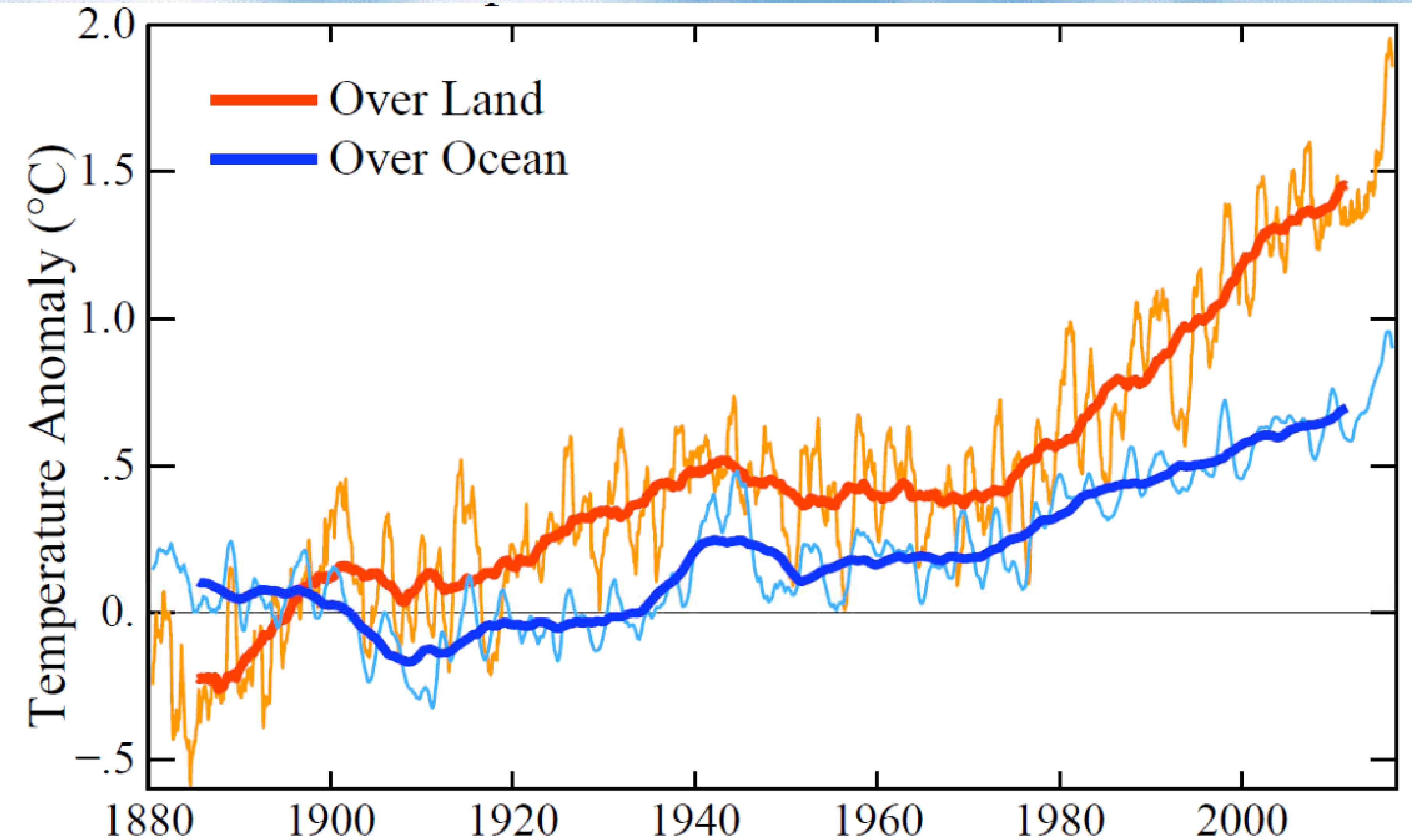


Faster immediate CO2 emission reductions limit cumulative CO2 emissions shown in panel **(c)**.

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

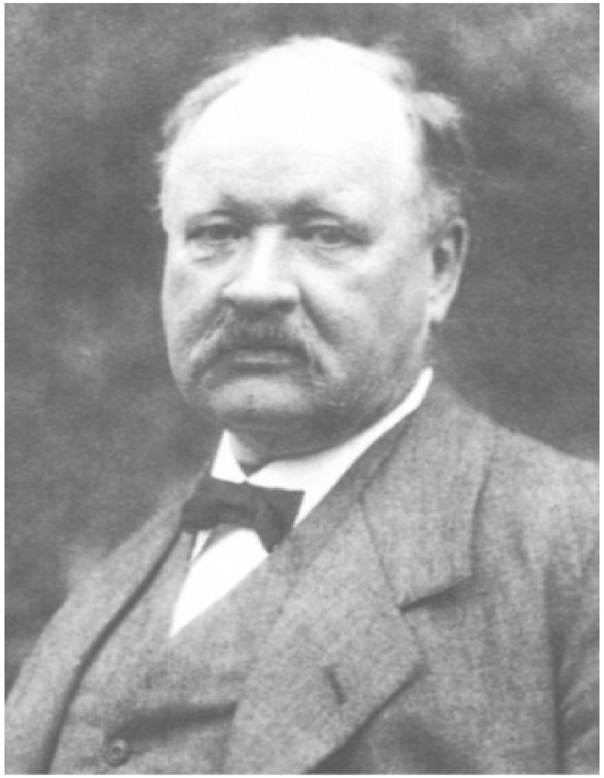
Maximum temperature rise is determined by cumulative net CO2 emissions and net non-CO2 radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.

Increase in temperature in continental areas: about 1.5 degrees
Surface temperatures relative to 1880-1920 mean



Jim Hansen NASA GISS, 2017

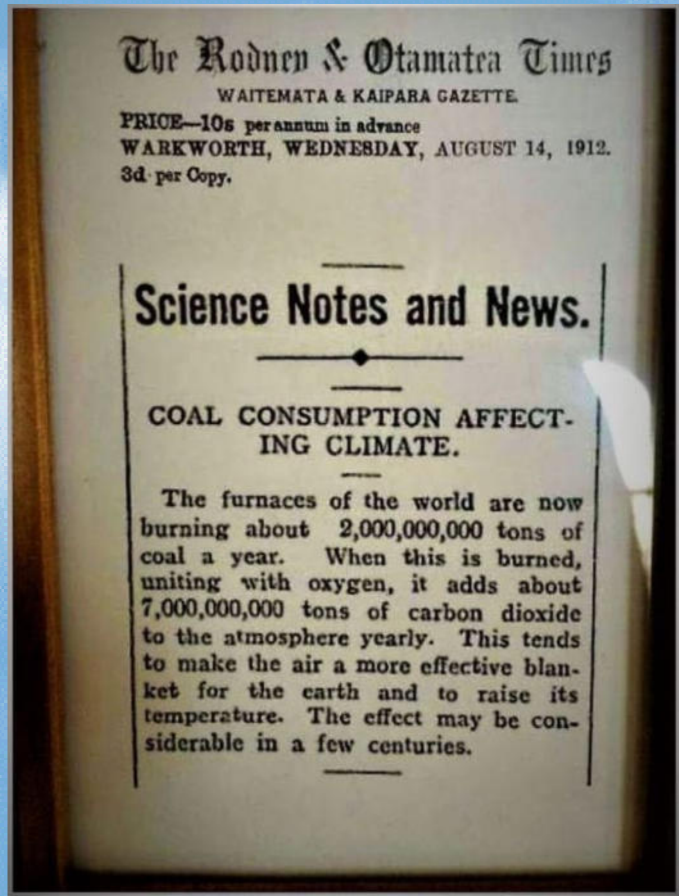
In 1896, the first climate prediction: Svante Arrhenius



Arrhenius

Arrhenius quantified in 1896 the Temperature change from doubling CO2 concentration: about 5 C. This was based on the concept of the ”glass bowl” effect from Joseph Fourier in 1824

In the press in 1912



The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

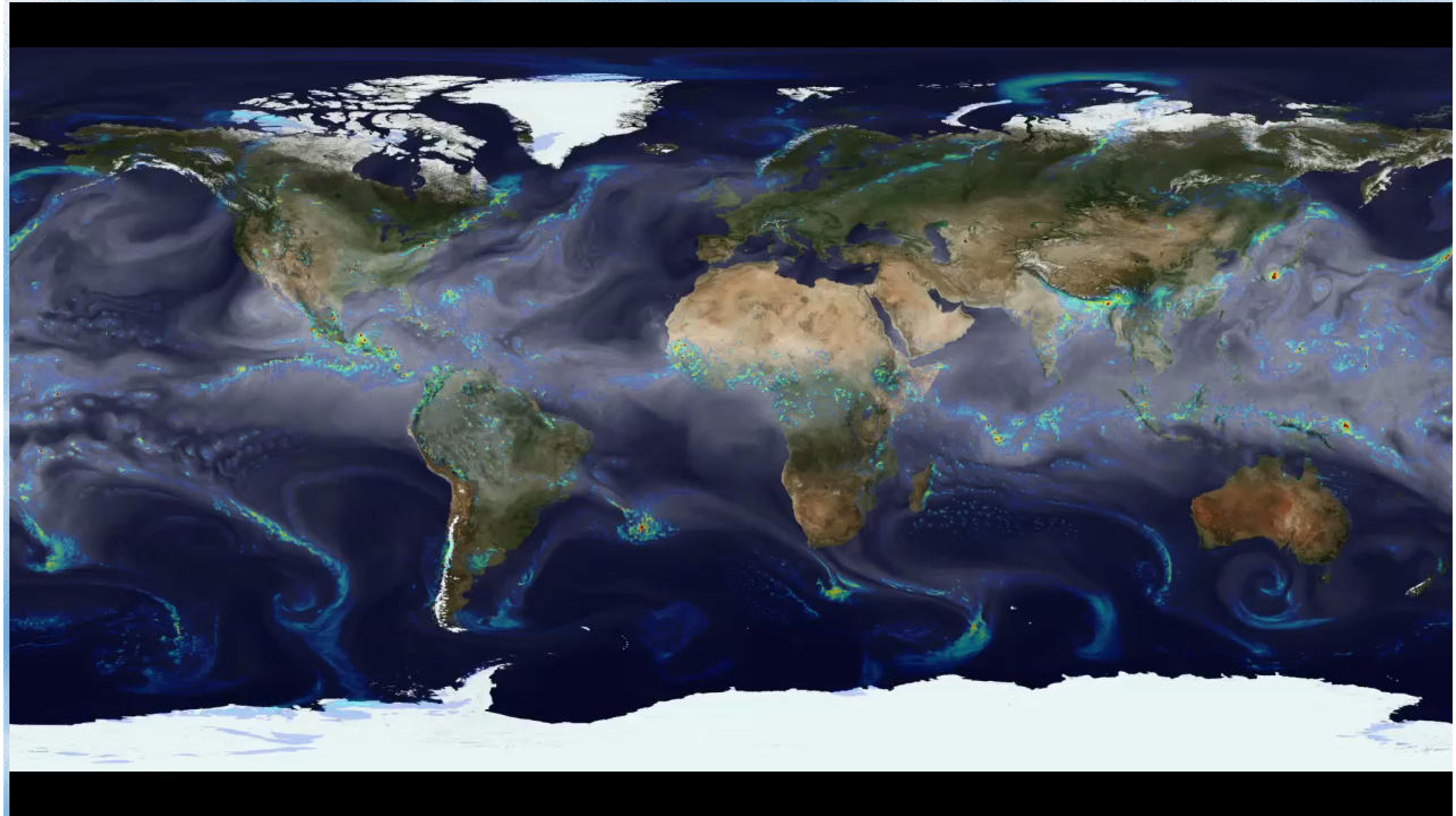
3d per Copy.

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.

Moisture and precipitation in the atmosphere



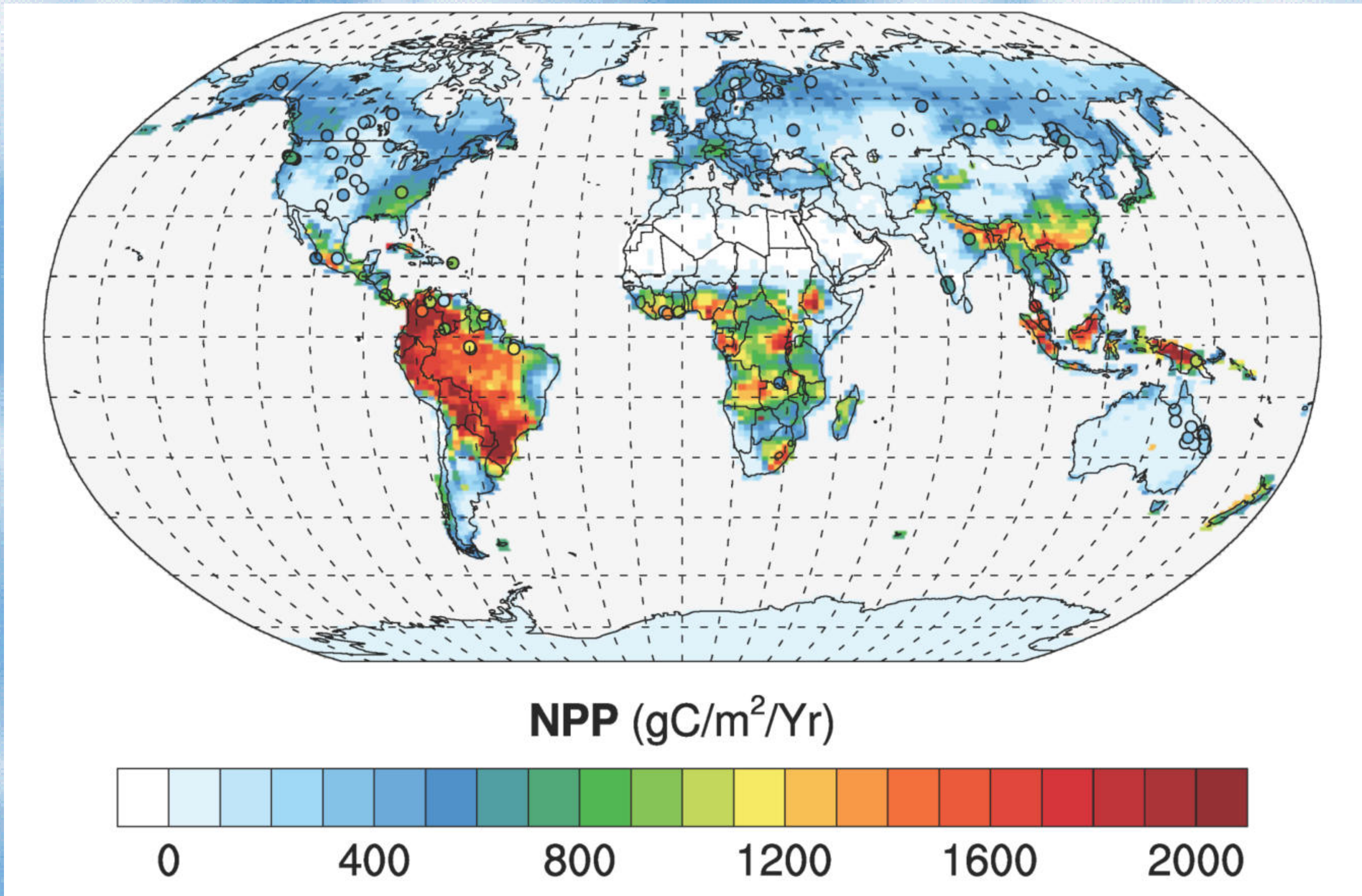
To study the effects of precipitation and how it influences other phenomena, scientists study moisture and precipitation in the atmosphere. Satellite observations cover broad areas and provide more frequent measurements that offer insights into when, where, and how much it rains or snows worldwide. Researchers 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.

Chemistry of the Atmosphere: Field Experiment in Brazil (CAFE-Brazil)

Max Planck Institute for Chemistry (coordinator)
Karlsruhe Institute of Technology, Research Center Jülich,
University of Frankfurt, University of Mainz

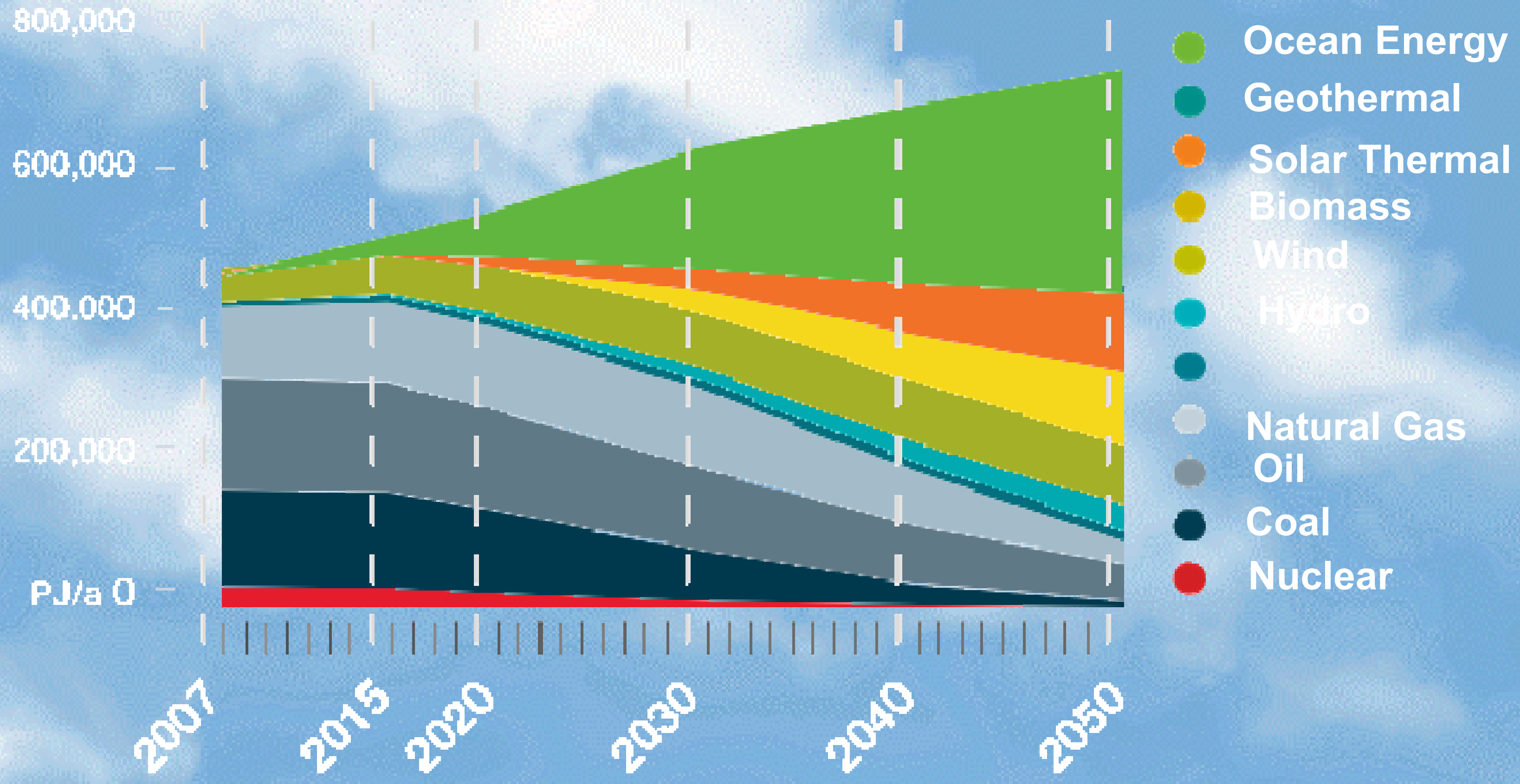
In collaboration with Centre for Weather Forecasting and Climate studies (INPA) and the University of Sao Paulo

Global Net Primary Productivity NPP: South America is key…



Ecosystem Model Data Model Intercomparison (EMDI) project

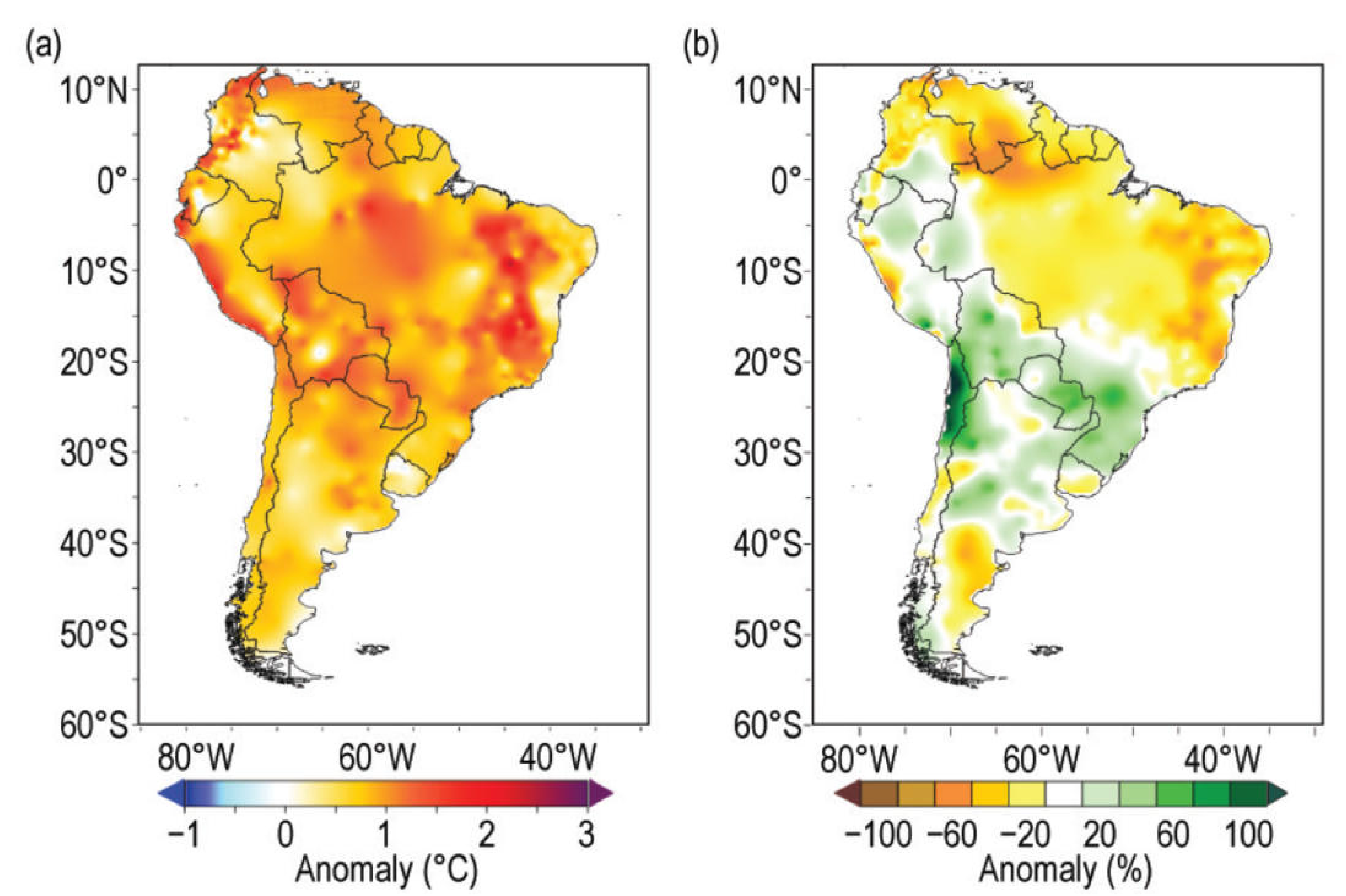
We already have the technology to eliminate fossil fuels



Advanced Energy [R]evolution Scenario 2010


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

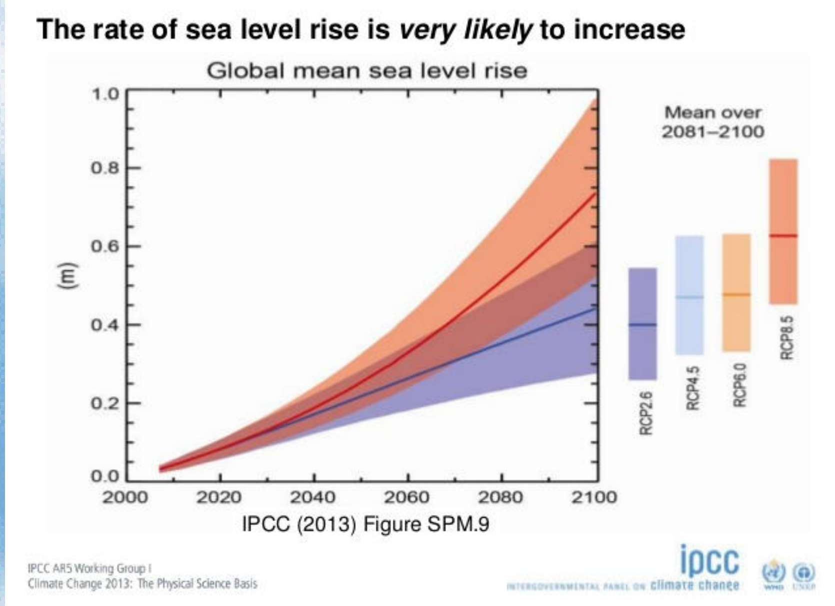
South American (a) temperature anomalies (°C) and (b) precipitation anomalies

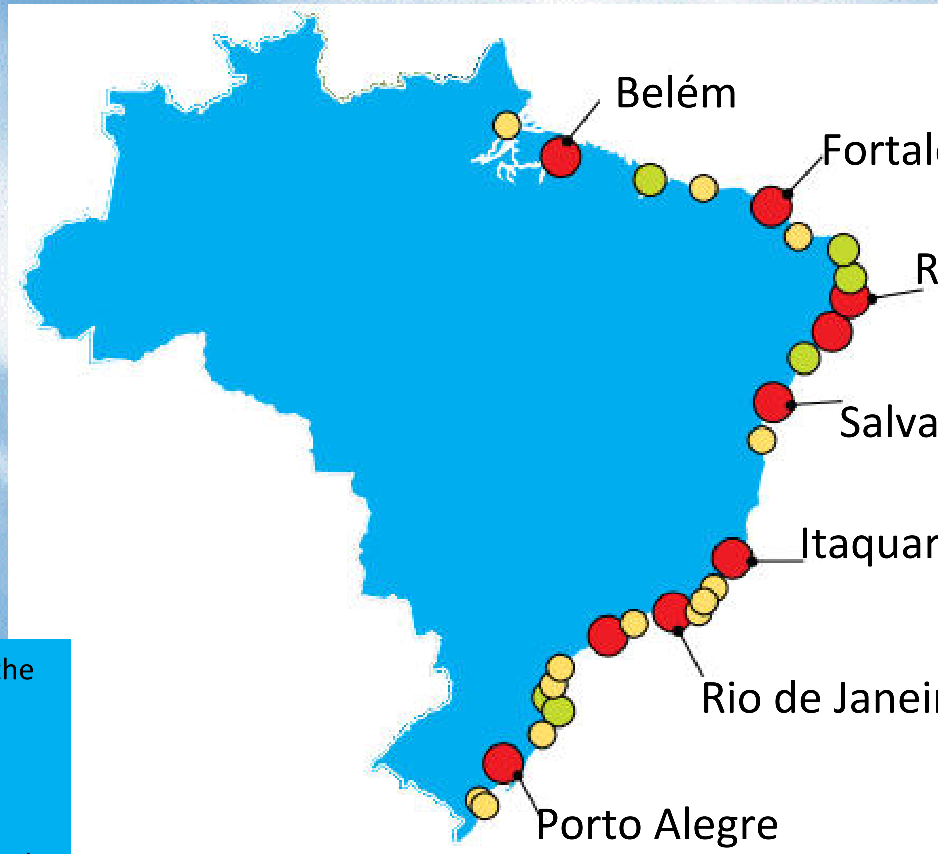


base period: 1981–2010.

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

Cidades brasileiras em risco pelo aumento do nivel do mar





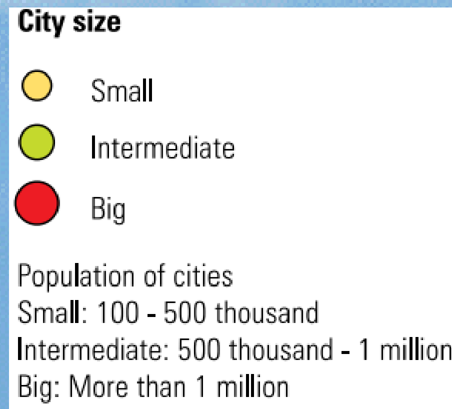
In the 20th century, sea levels rose by an estimated 23 cm, and the conservative global mean projections for sea-level rise between 1990 and 2080 range from 22 cm to 100 cm.

Oceans, which have been absorbing 80% of the temperature increase attributable to global warming, are expanding as ice sheets in the North and South poles melt.

These events have led to a rise in sea levels and increased flooding in coastal cities.

The projected rise in sea levels could result in catastrophic flooding of coastal cities.

Thirteen of the world's 20 megacities are situated along coastlines.



Source: *UN-HABITAT* Global Urban Observatory 2008 (adapted)

Human pertubations on the global carbon cycle

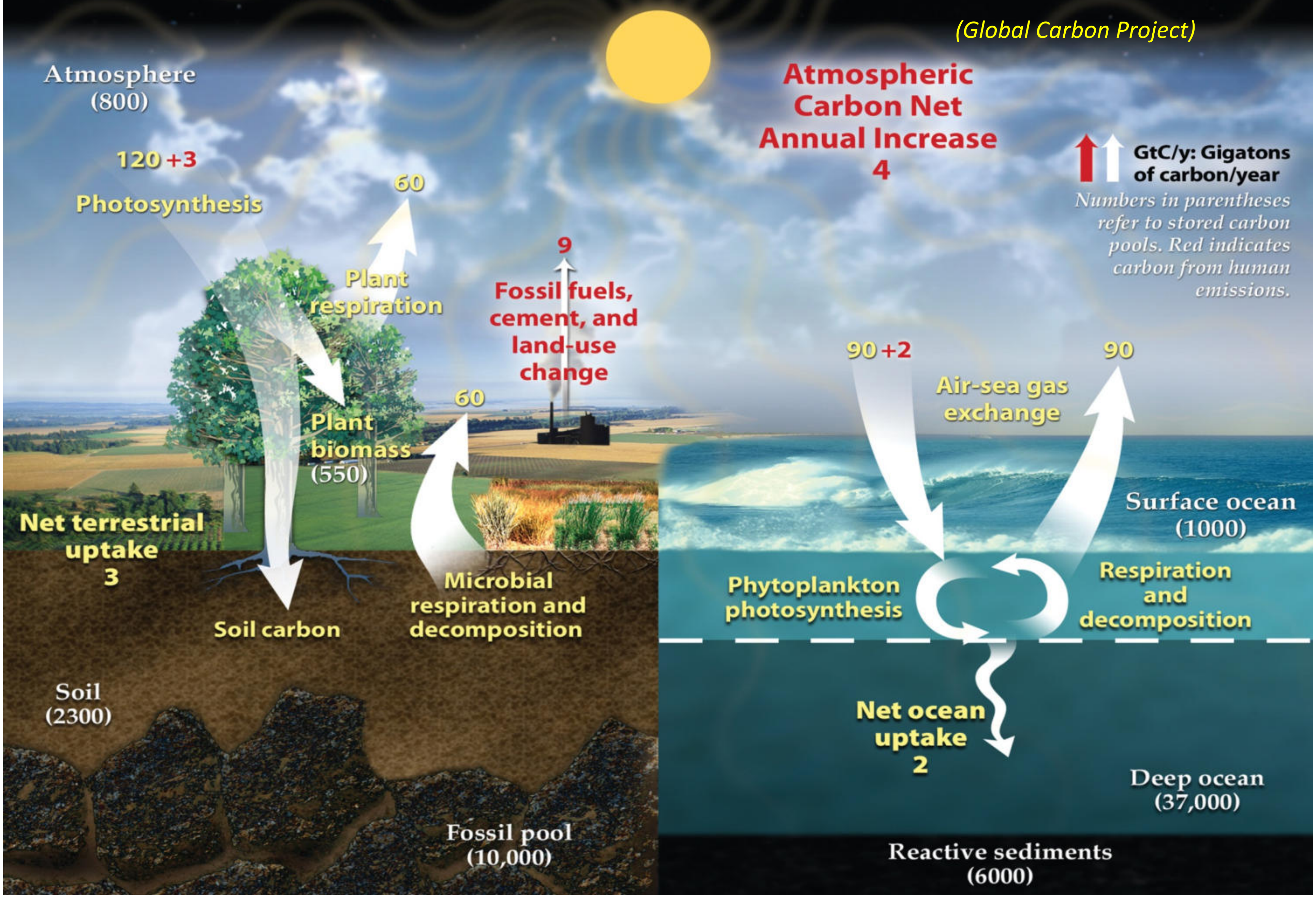
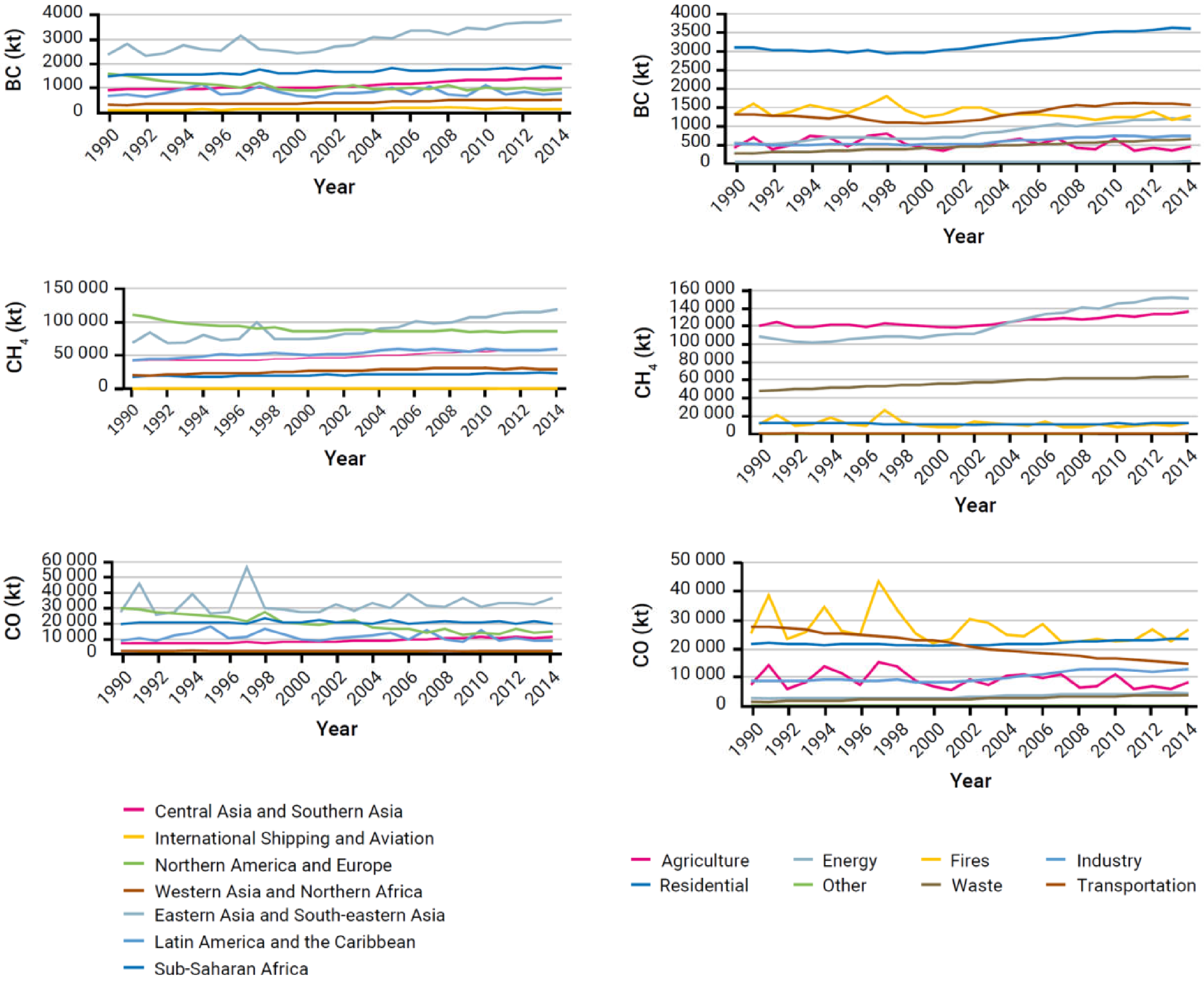
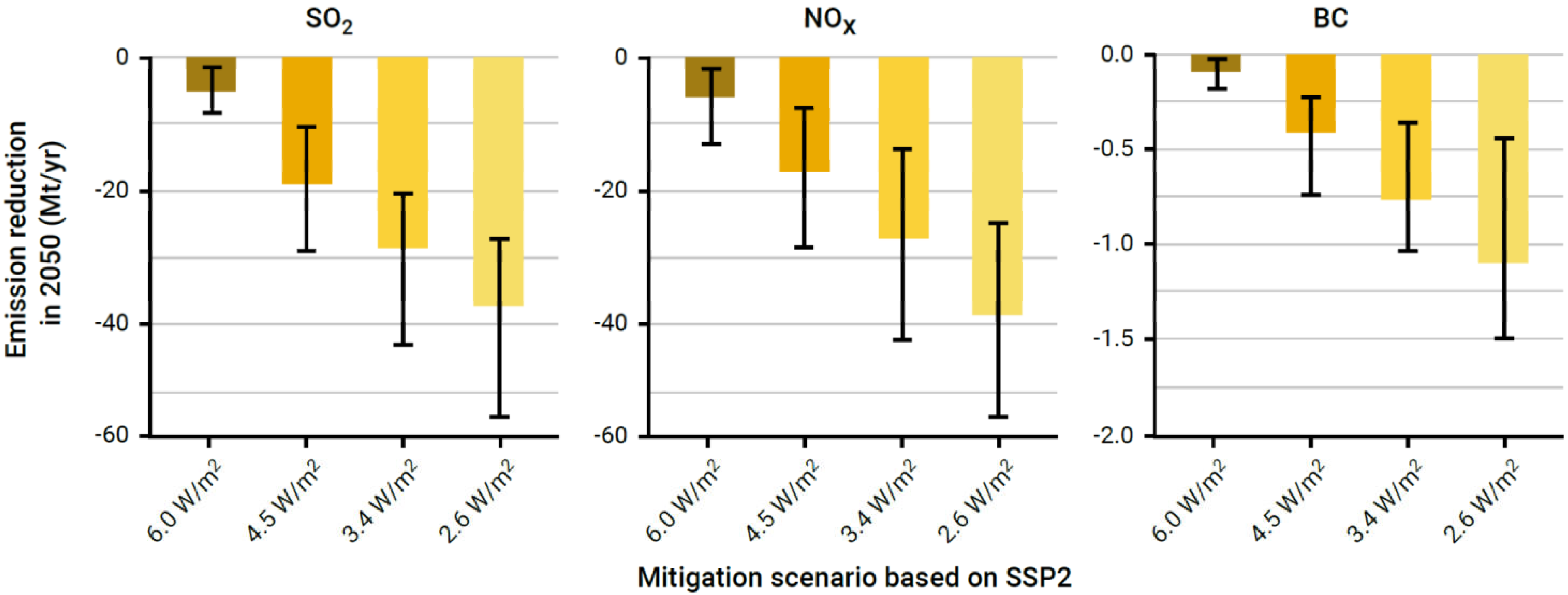


Figure 5.3: Annual emission trends from 1990 to 2014 in kilotons by pollutant, region and sector



Source: Hoesly *et al.* (2018).

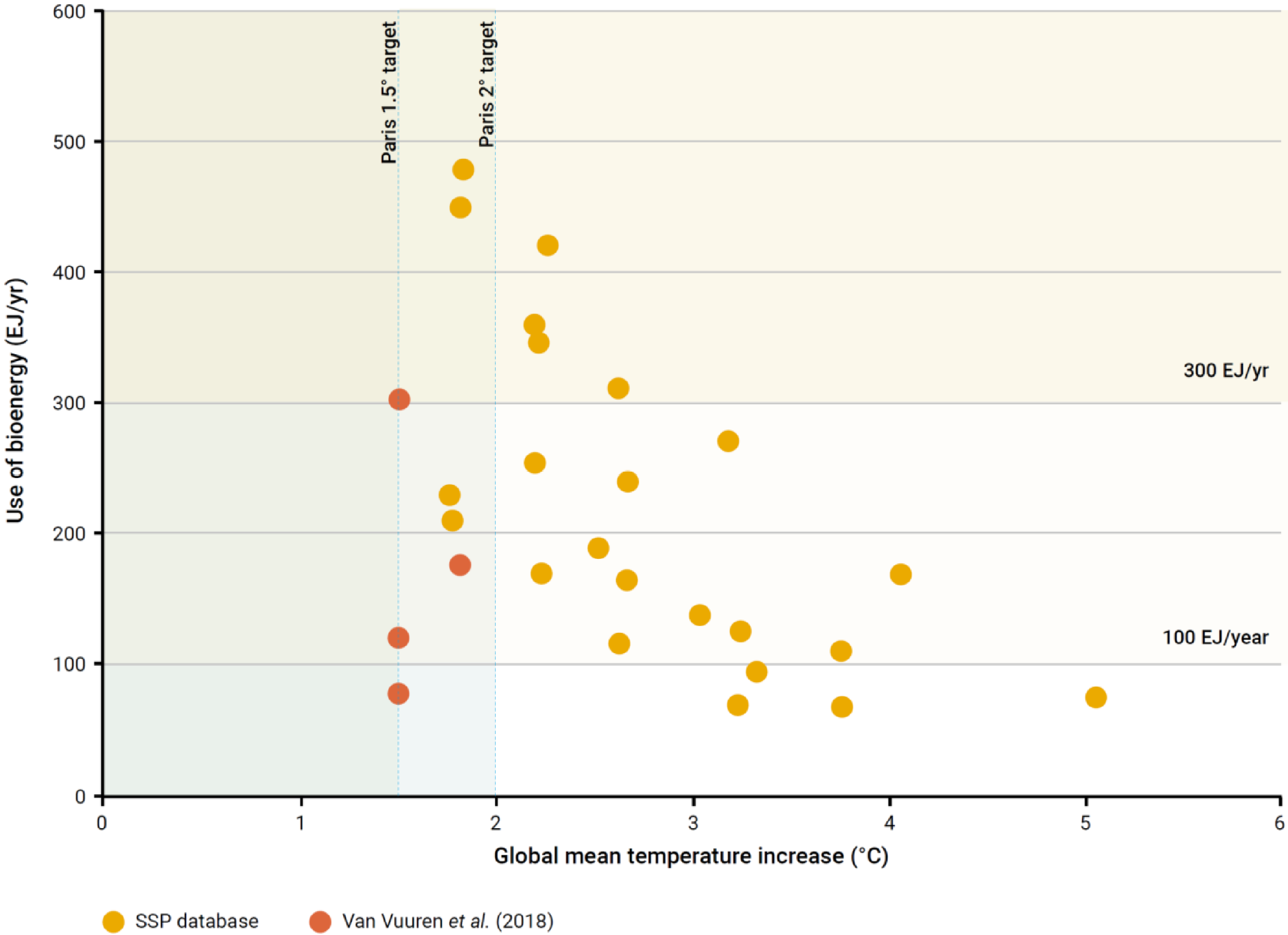
Figure 22.7b: Differences in air pollution emissions between various climate mitigation scenarios, and the SSP2 baseline



Error bars represent the range of all Integrated Assessment Models (IAMs) included in Rao *et al.* (2017).

Source: Rao *et al.* (2017).

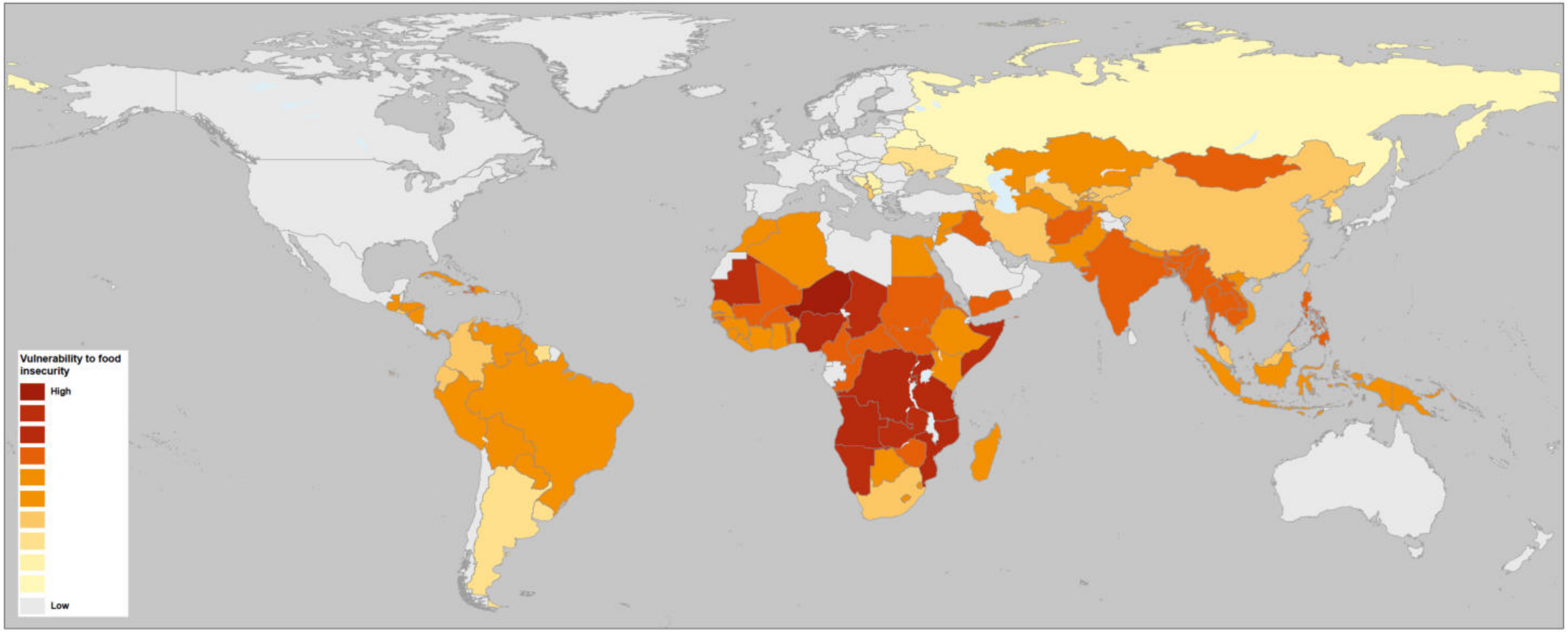
Figure 22.10: Global mean temperature increase in 2100 versus bioenergy use in various SSP reference scenarios and derived mitigation scenarios



The different background colors indicate the Paris Climate Targets (vertical lines, starting at 1.5° and 2°C) and the range for sustainable biodiversity supply indicated by the Intergovernmental Panel on Climate Change (IPCC) (IPCC indicated 100 exajoules/year was most likely available; 300 exajoules/year could be available).

Source: Riahi *et al.*, 2017; Vuuren *et al.* (2018).

Figure 8.19: Potential impacts of climate change on food security



Source: Met Office Hadley Centre and World Food Programme (2018).

Table 21.1: Percentage of countries by region projected to achieve selected SDG targets in 2030

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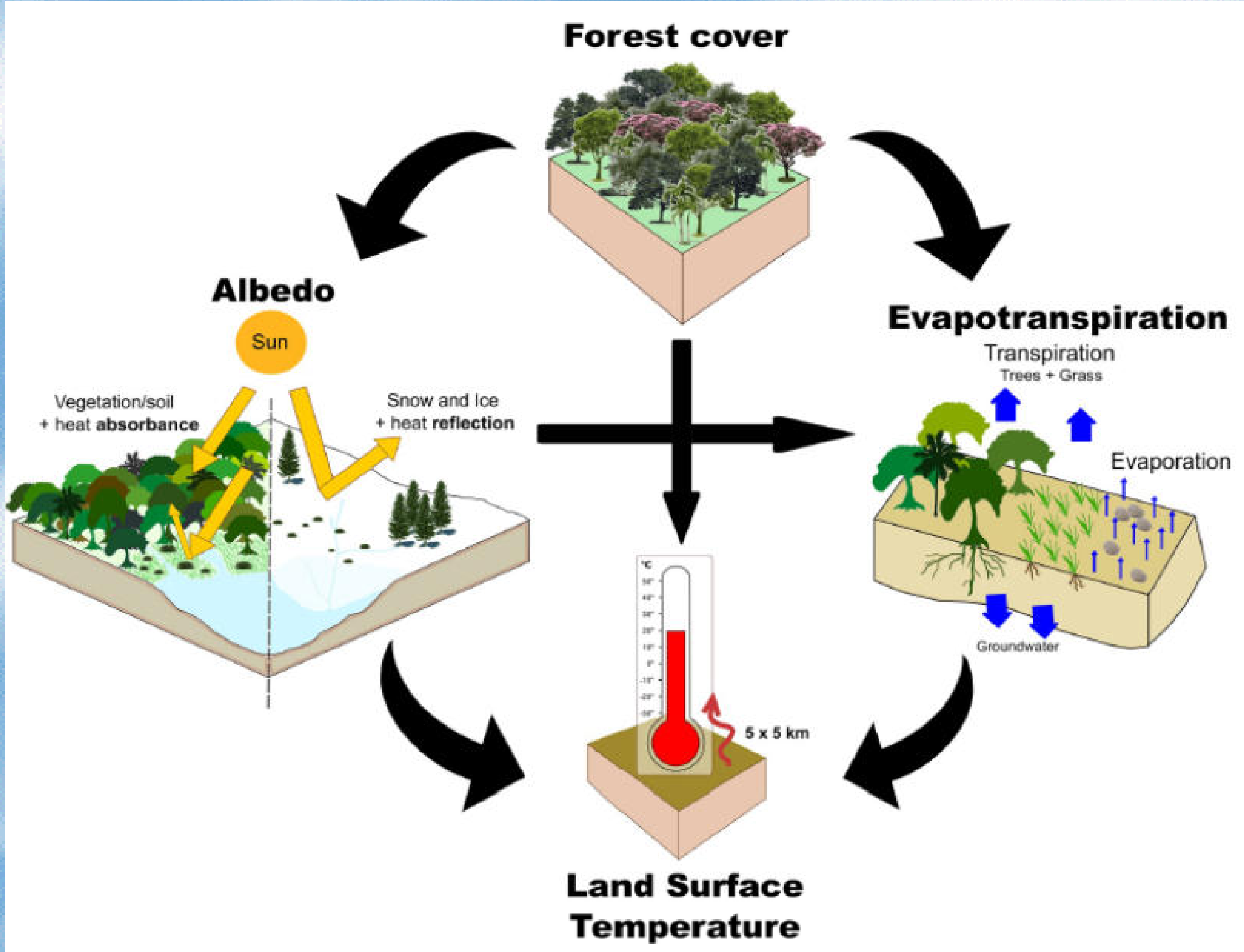
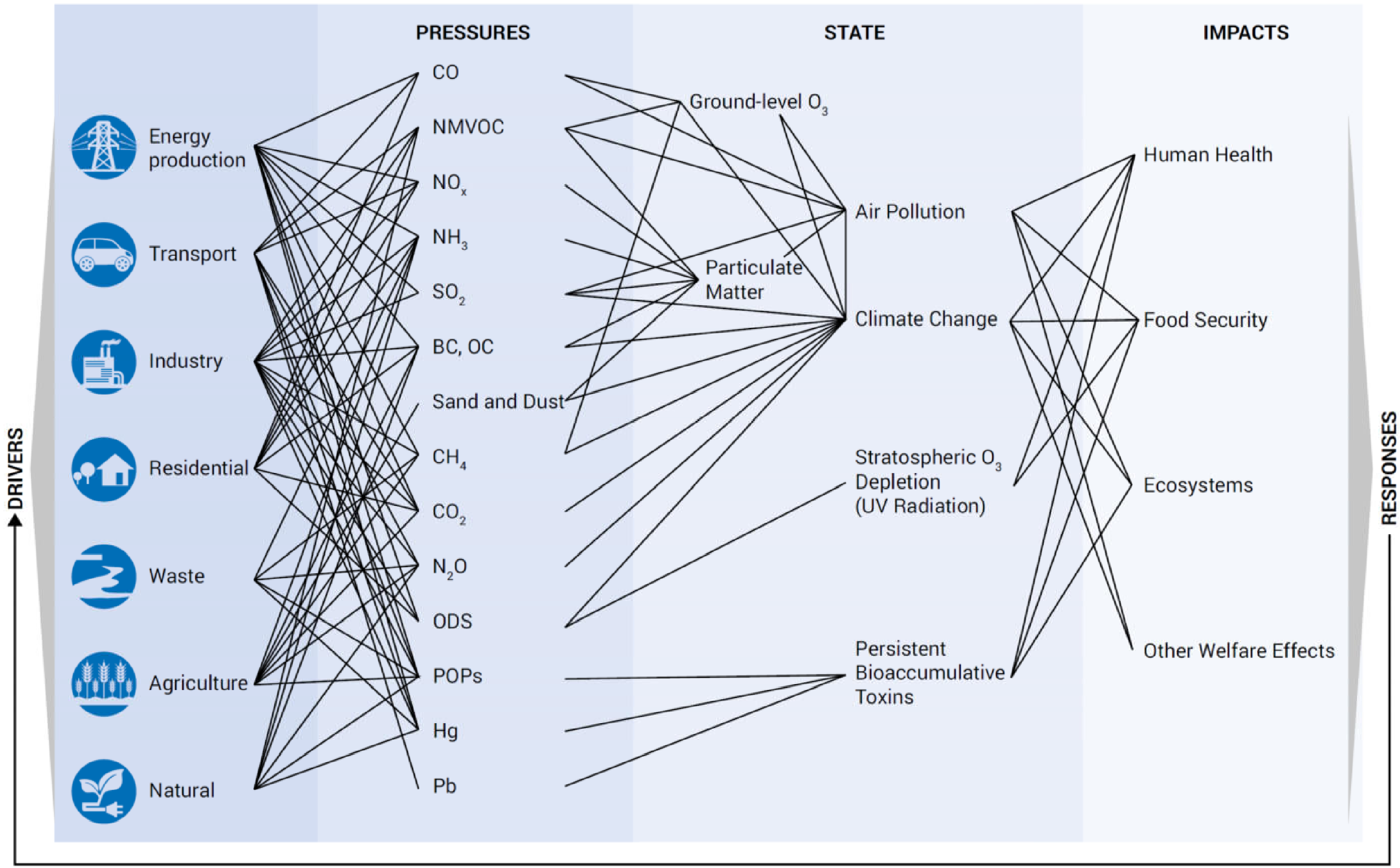
Extreme poverty	100	68	85	70	100	100	79	21	67
Hunger	95	32	70	26	100	100	43	10	48
Underweight children	82	48	30	26	100	100	14	0	37
Child mortality	98	90	90	74	100	50	71	6	67
Primary school completion	100	94	85	78	100	100	86	33	77
Lower secondary school	89	35	40	48	100	100	50	4	45
Access to safe water	98	94	95	70	100	100	93	17	72
Improved sanitation	80	29	65	43	100	100	43	4	44
Access to electricity	100	68	90	48	100	100	71	2	60

Source: Moyer and Hedden (2018).



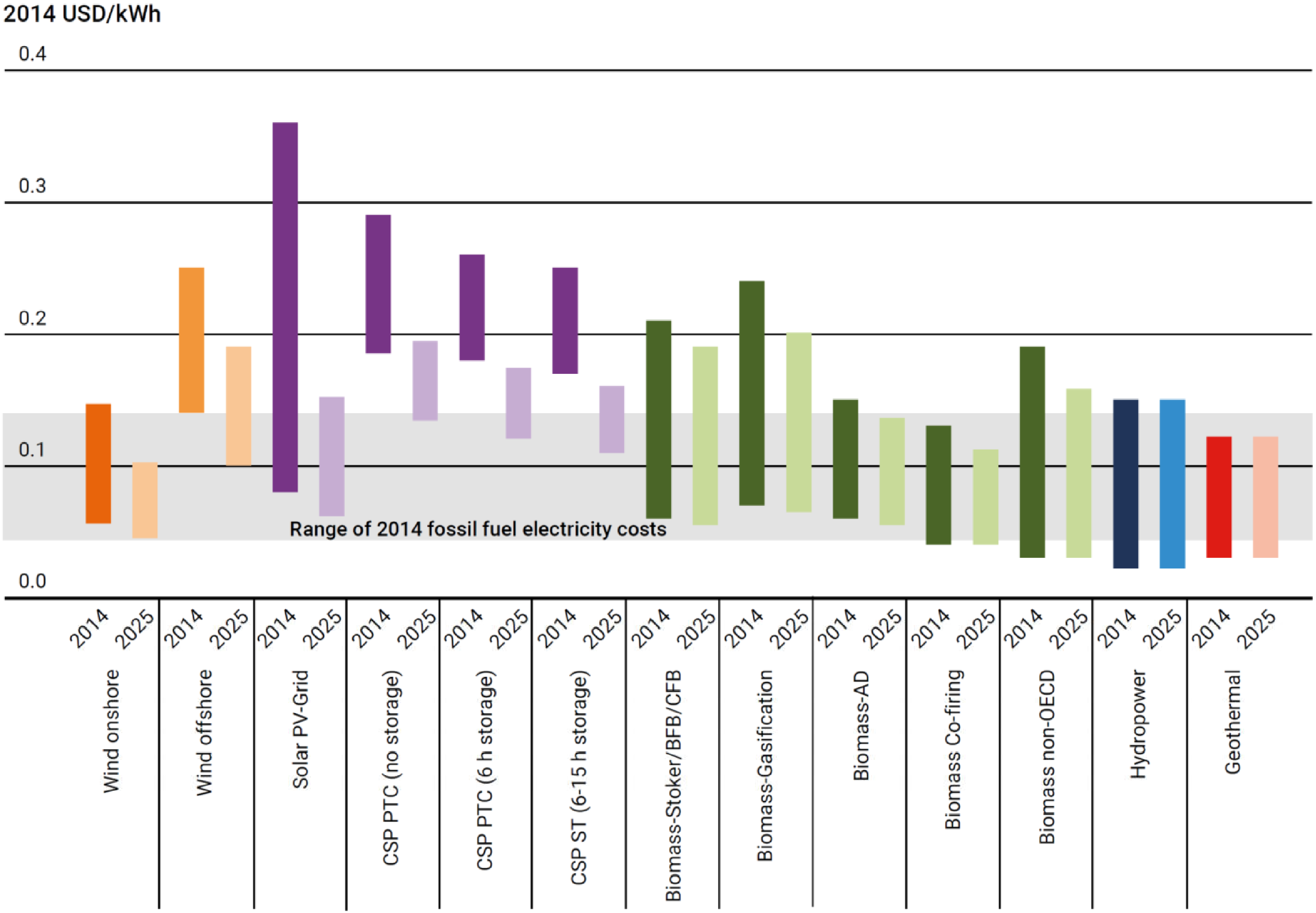
PLSOne 2019 - https://doi.org/10.1371/journal.pone.0213368.g002

Figure 5.1: Primary linkages between pressures, state and impacts of atmospheric change



This figure is intended as a road map for the reader, showing the relationships between the main topics and pollutants discussed in this chapter. Chemical symbols and abbreviations are defined in Table 5.1.

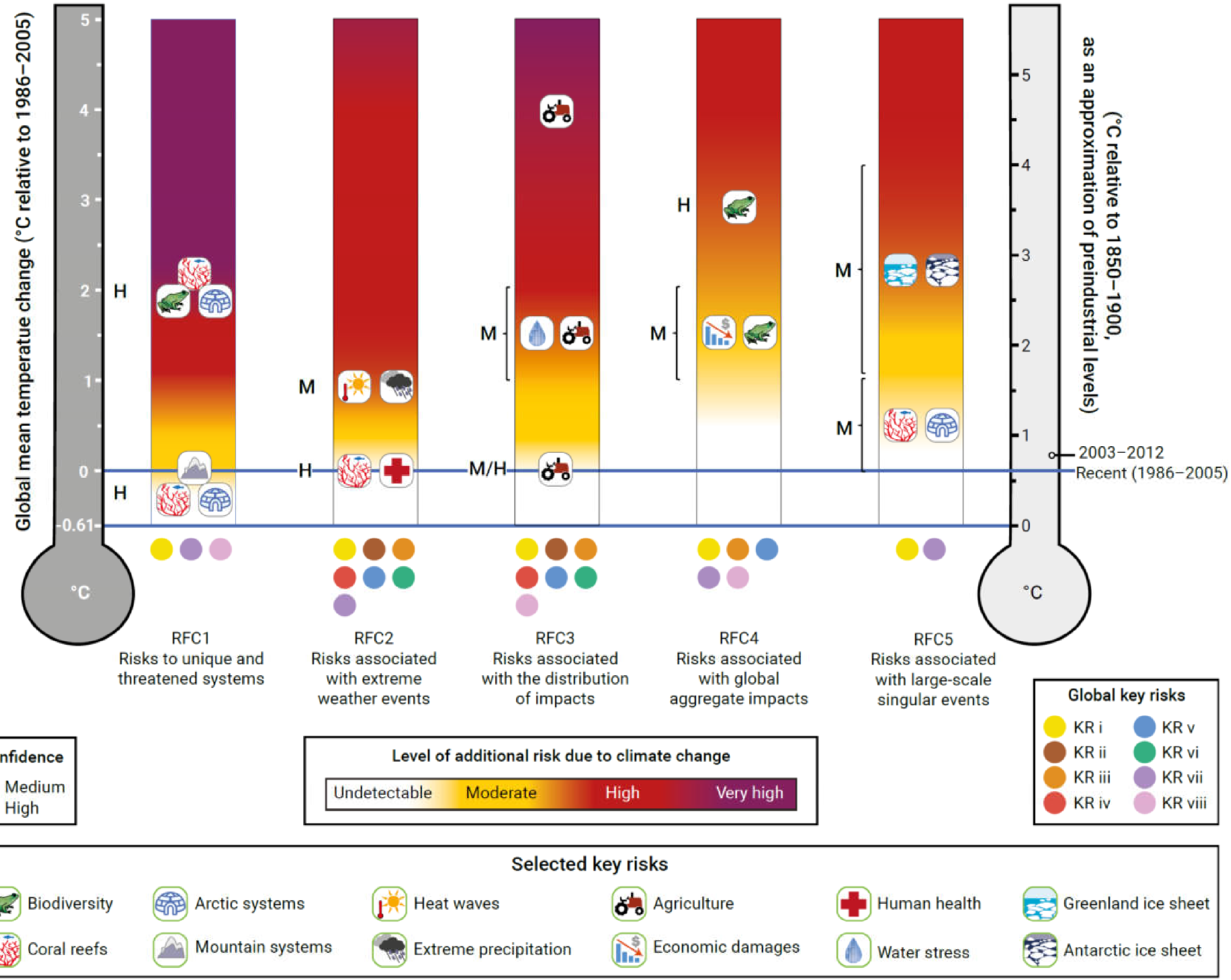
Figure 4.12: Ranges of levelized cost of electricity for different renewable power generation technologies, 2014 and 2025



Source: IRENA (2015).

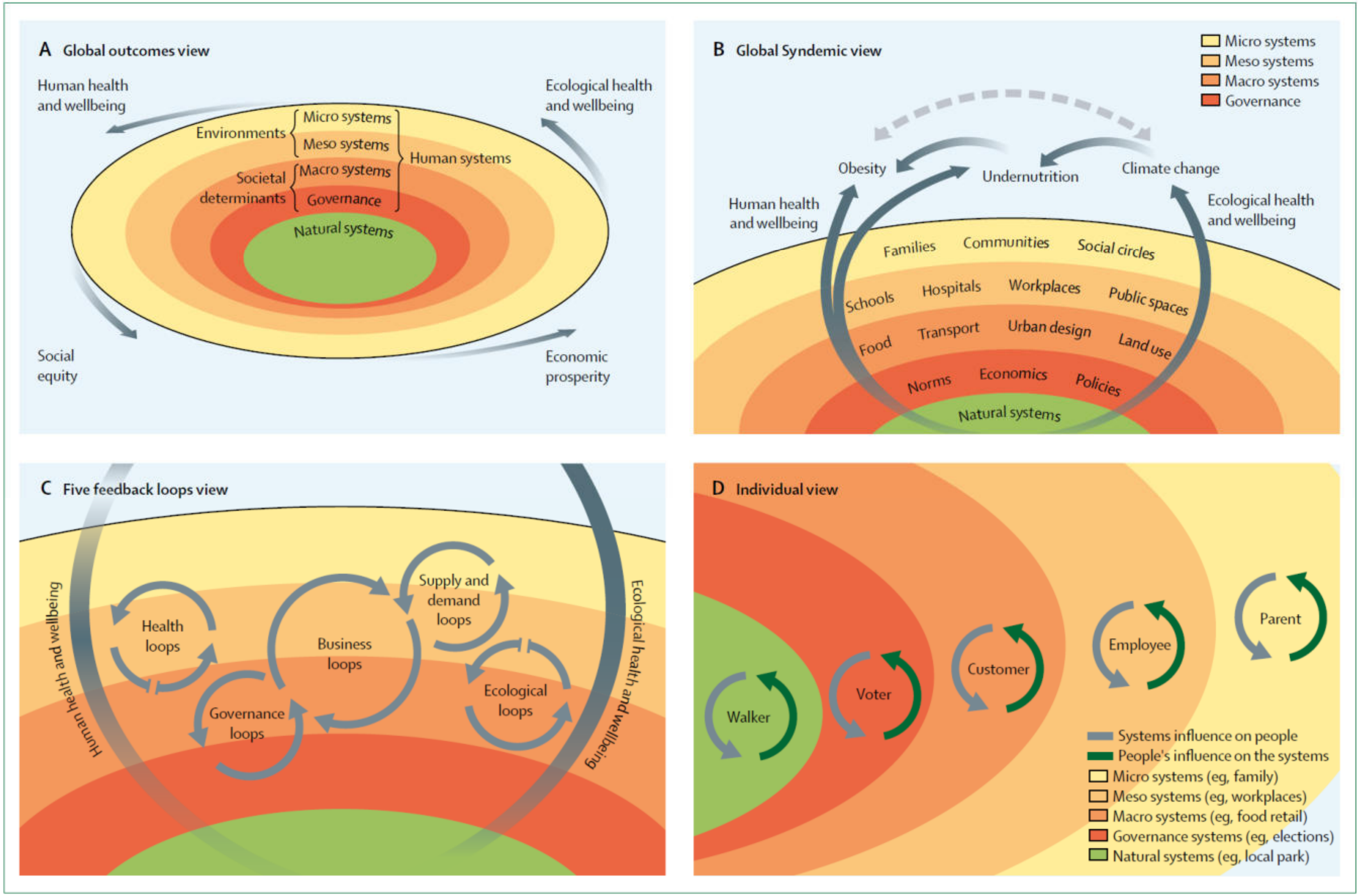

A imagem não pode ser exibida. Talvez o computador não tenha memória suficiente para abrir a imagem ou talvez ela esteja corrompida. Reinicie o computador e abra o arquivo novamente. Se ainda assim aparecer o x vermelho, poderá ser necessário excluir a imagem e inseri-la novamente.

Figure 2.21: The enhanced burning embers diagram, providing a global perspective on climate-related risks



Source: O'Neill *et al.* (2017, p. 30)

The Systems Outcomes Framework - consequences of intersecting natural and human systems



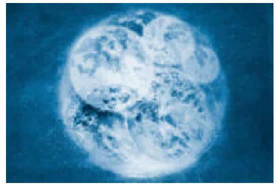
The sequence of figures below shows progressively zoomed-in views from the global outcomes view of the consequences of intersecting natural and human systems (A); to The Global Syndemic view
of the interaction and common drivers of obesity, undernutrition, and climate change (B); to the Five Feedback Loops view (C); and the individual view (D).

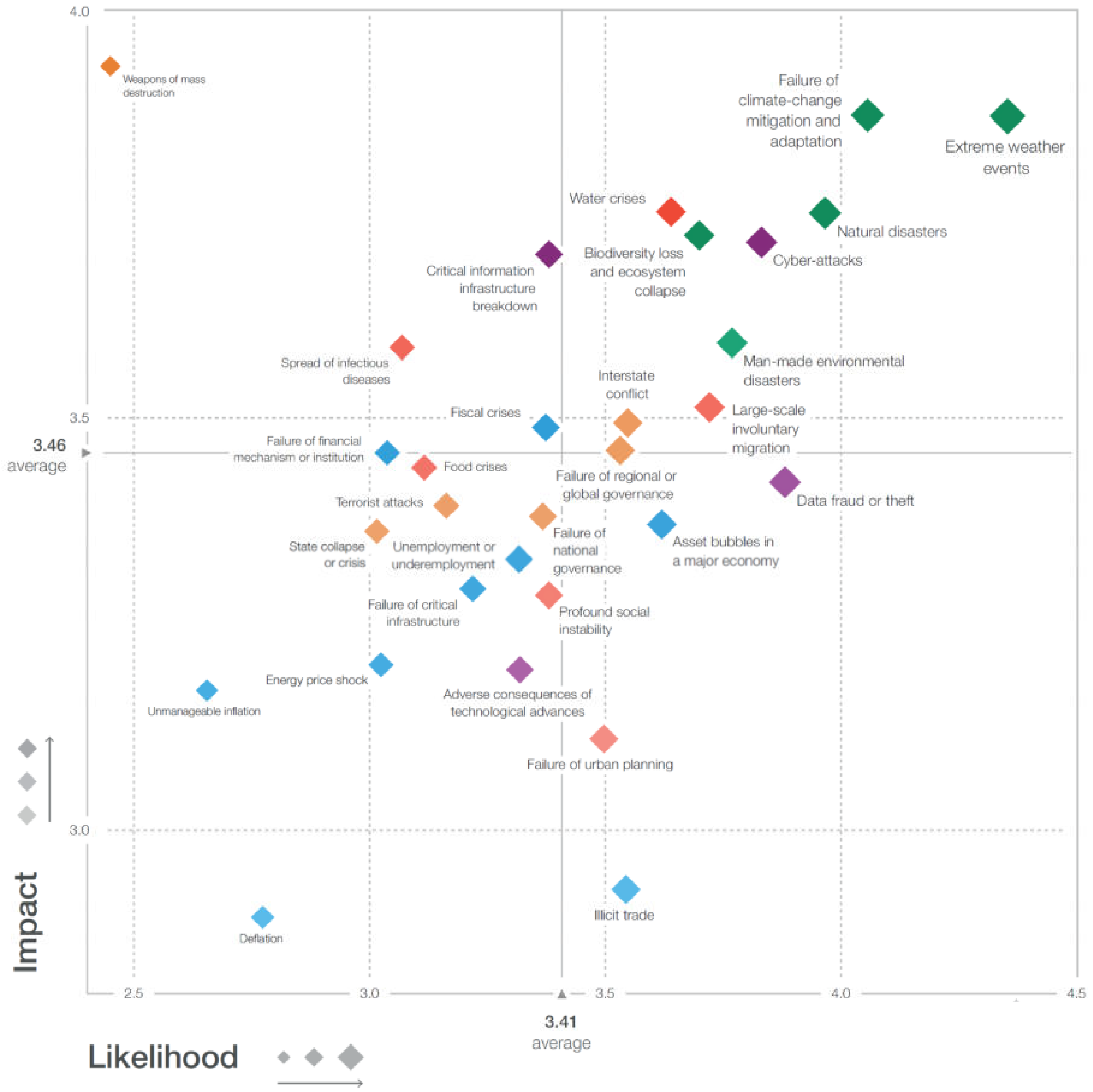
The Lancet: The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report, January 2019

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

World Economic Forum Davos: The Global Risks Landscape 2019

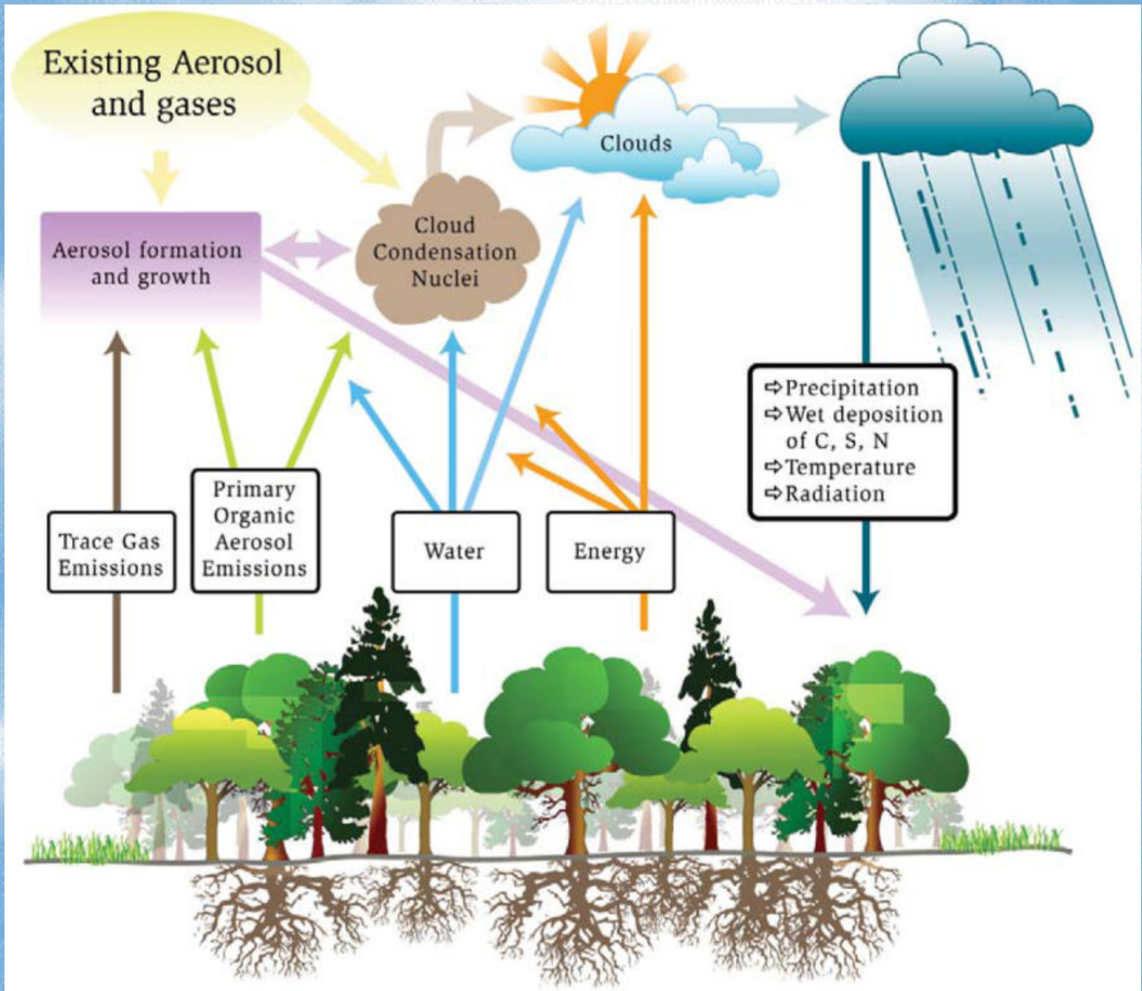




Source: World Economic Forum Global Risks Perception Survey 2019

There are strong and complex links between the forest biology, and the physics and chemistry of the atmosphere

Natural System



The Transition

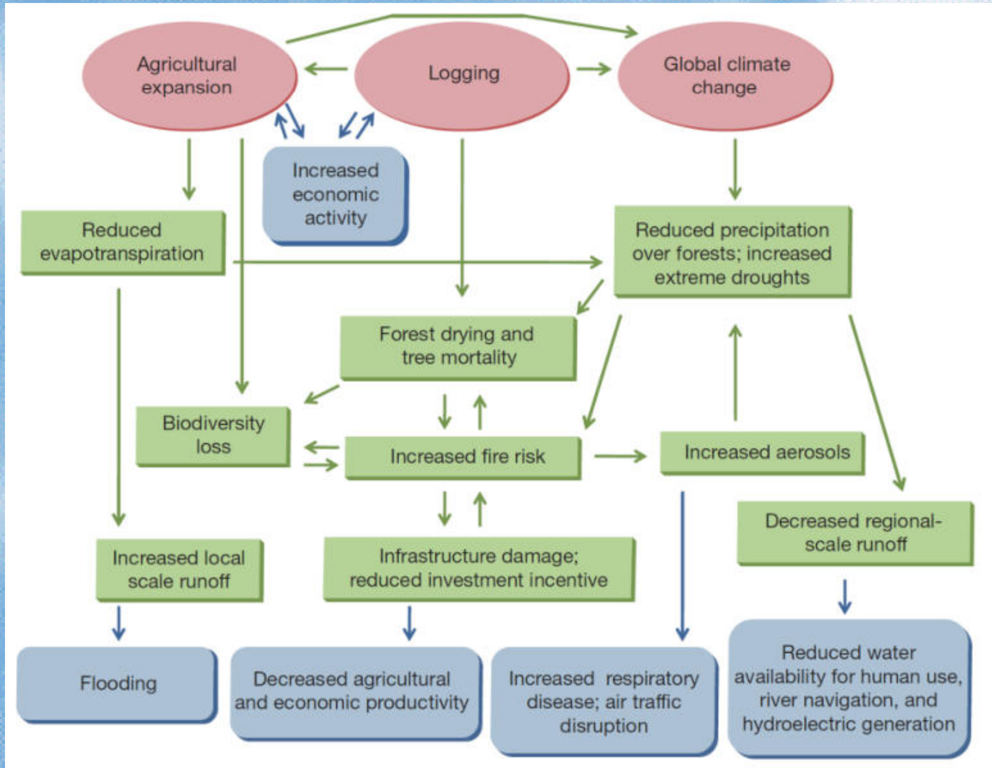
REVIEW

doi:10.1038/nature10717

The Amazon basin in transition

Eric A. Davidson[1], Alessandro C. de Araújo[2,3], Paulo Artaxo[4], Jennifer K. Balch[1,5], I. Foster Brown[1,6], Mercedes M. C. Bustamante[7], Michael T. Coe[1], Ruth S. DeFries[8], Michael Keller[9,10], Marcos Longo[11], J. William Munger[11], Wilfrid Schroeder[12], Britaldo S. Soares-Filho[13], Carlos M. Souza Jr[14] & Steven C. Wofsy[11]

Agriculture expansion and climate variability are critical ingredients on Amazonian transition. Energy balance and hydrological cycles changes are already observed in Amazonia.



Interactions between land use change and climate change are major drivers for changes in Amazonia.


But, the reality of agricultural expansion in the Amazon is one of fire and forest destruction


Deforestation


Fire…

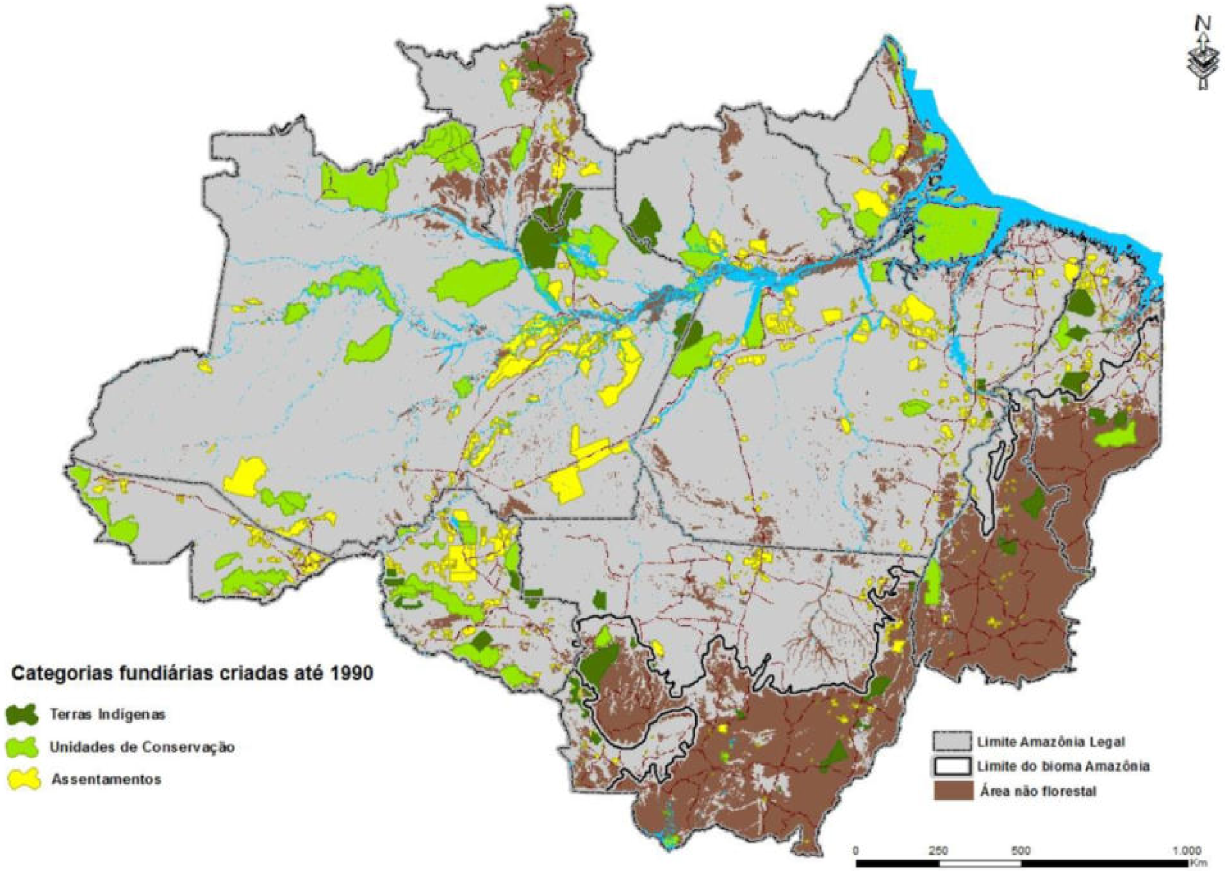

Selective
logging...

Protected Areas – Brazilian Amazon

1990

 # Indigenous Lands: 54
Area: 11 million ha

 # Protected Areas: 65
Area: 33 million ha



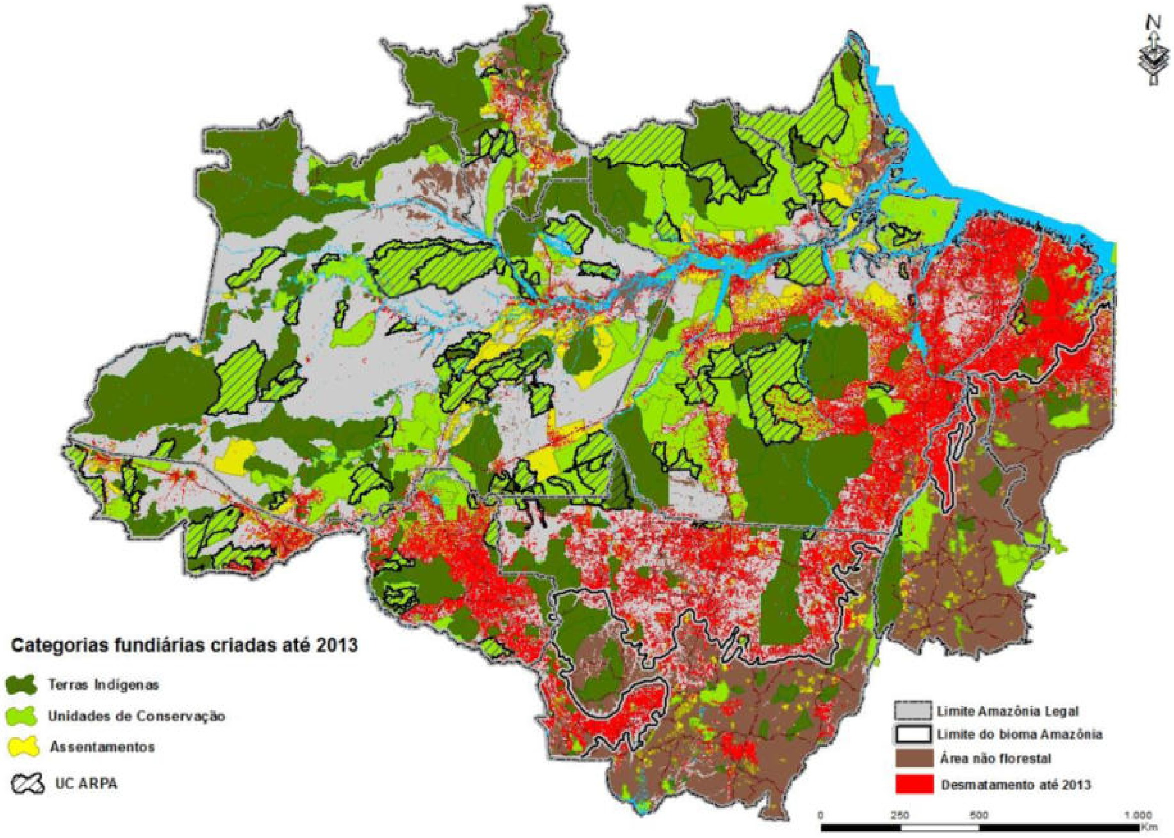
Protected Areas – Brazilian Amazon

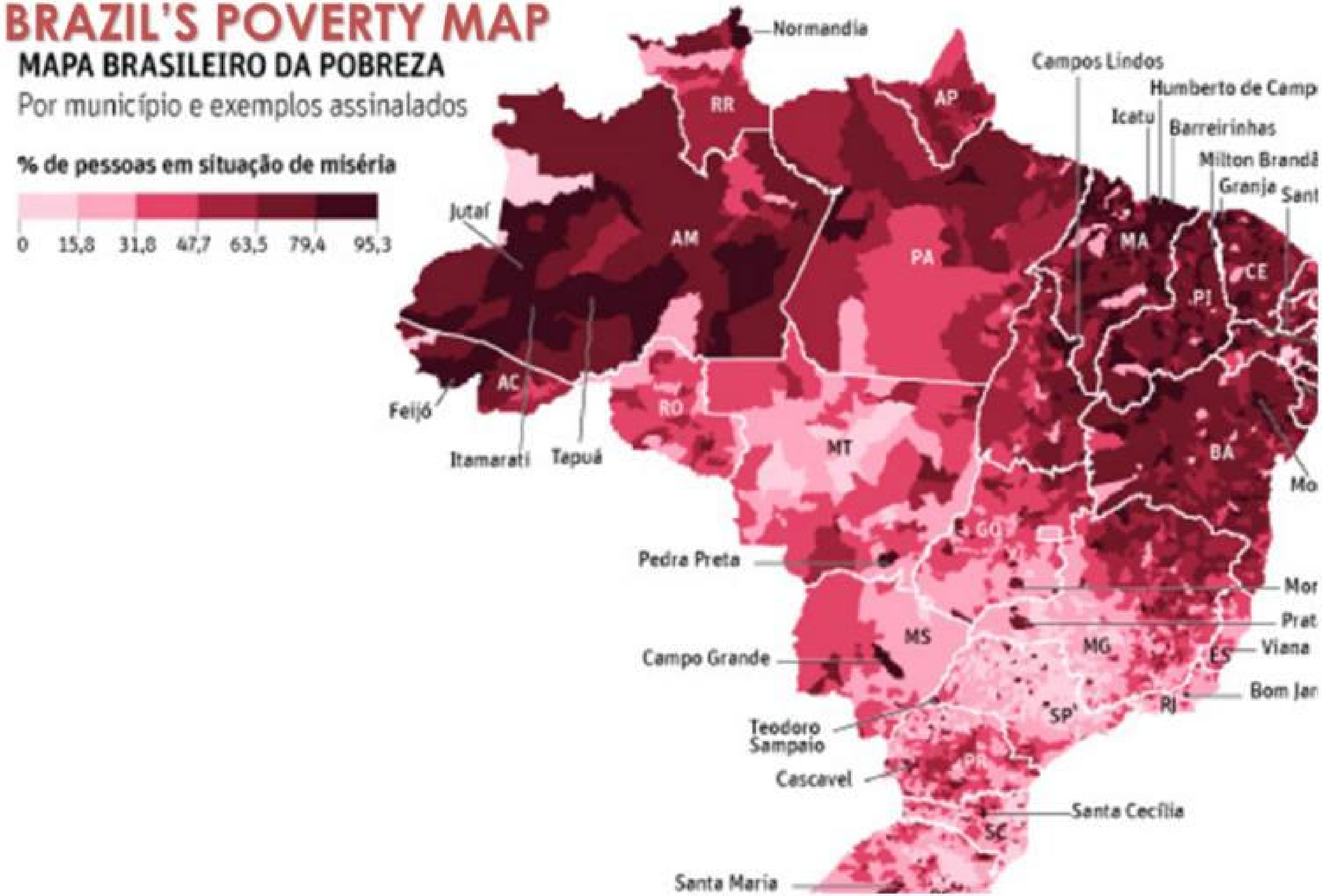
Contribuições do INCT-MC

2013

 # Indigenous Lands: 381
Area: 112 million ha

 # Protected Areas: 311
Area: 125 million ha





Source: IBGE (2014)

PROTECTED AREAS

One-third of global protected land is under intense human pressure

Kendall R. Jones,[1,2]* Oscar Venter,[3] Richard A. Fuller,[2,4] James R. Allan,[1,2] Sean L. Maxwell,[1,2] Pablo Jose Negret,[1,2] James E. M. Watson[1,2,5]

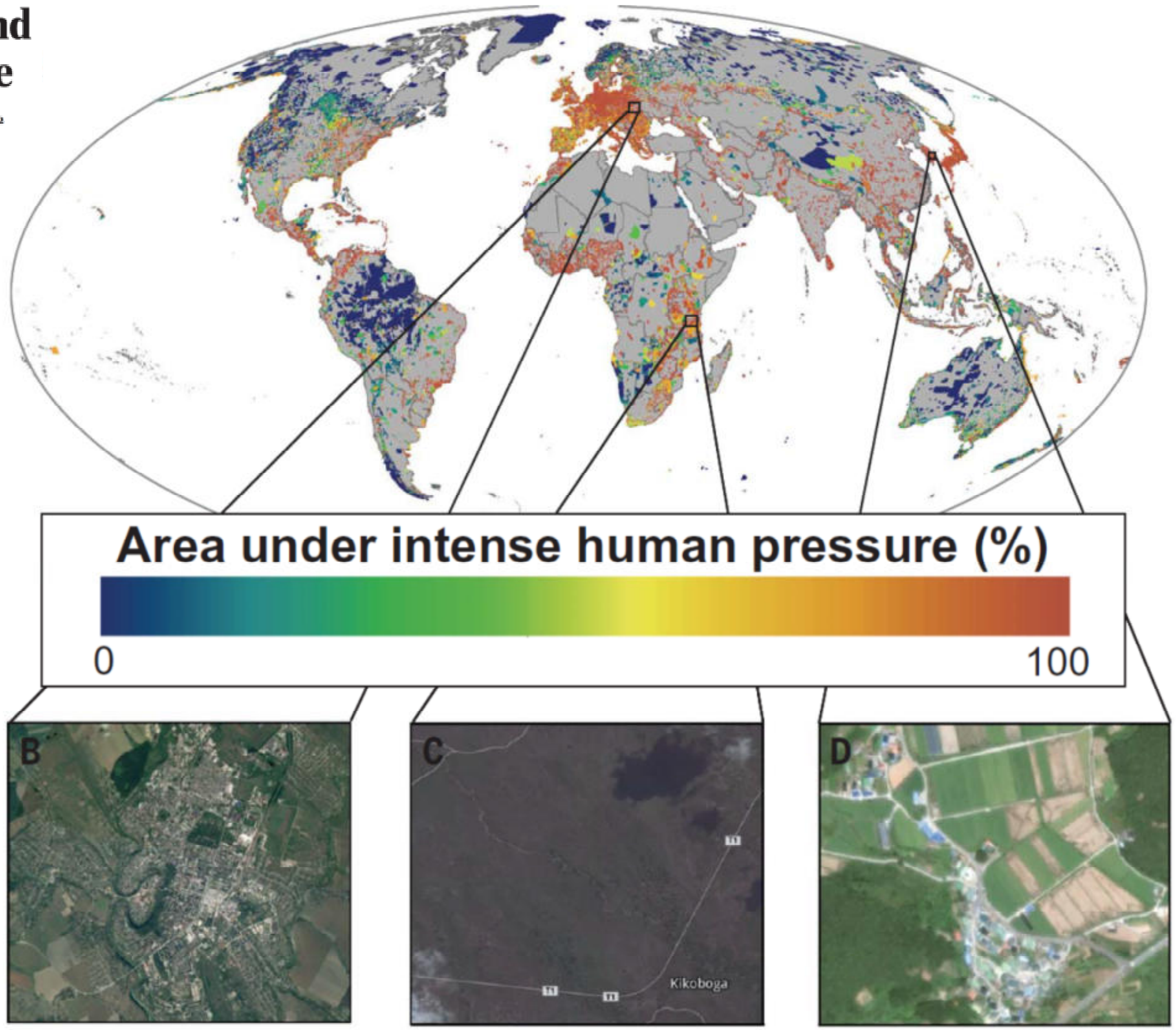
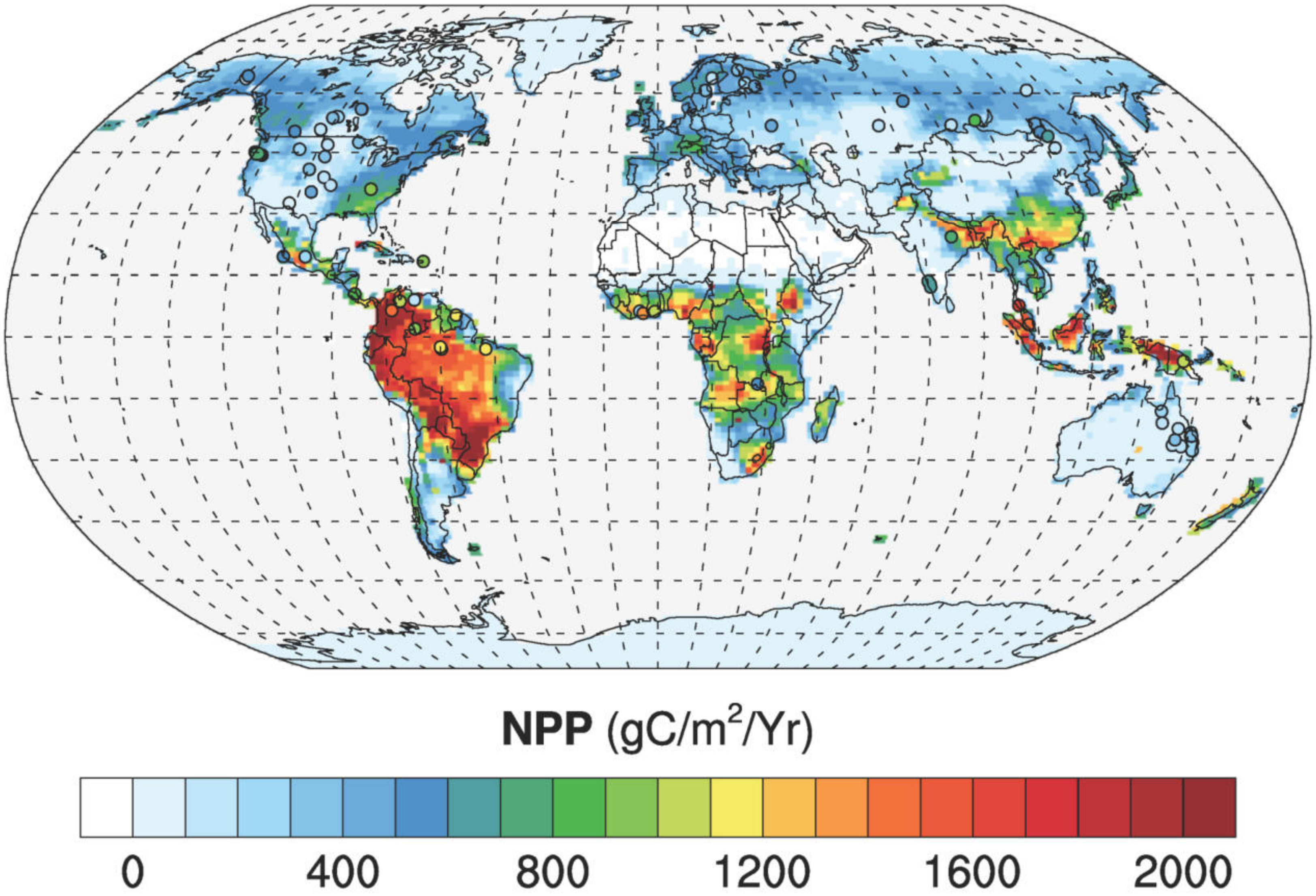


Fig. 1. Human pressure within protected areas. (**A**) Proportion of each protected area that is subject to intense human pressure, spanning from low (blue) to high (orange) levels. (**B**) Kamianets-Podilskyi, a city within Podolskie Tovtry National Park, Ukraine. (**C**) Major roads fragment habitat within Mikumi National Park, Tanzania. (**D**) Agriculture and buildings within Dadohaehaesang National Park, South Korea. [Photo credits: Google Earth]

Science May 2018

Global Net Primary Productivity NPP: South America is key…



Ecosystem Model Data Model Intercomparison (EMDI) project

Simulated rainforest biomass under climate change and different plant trait diversity

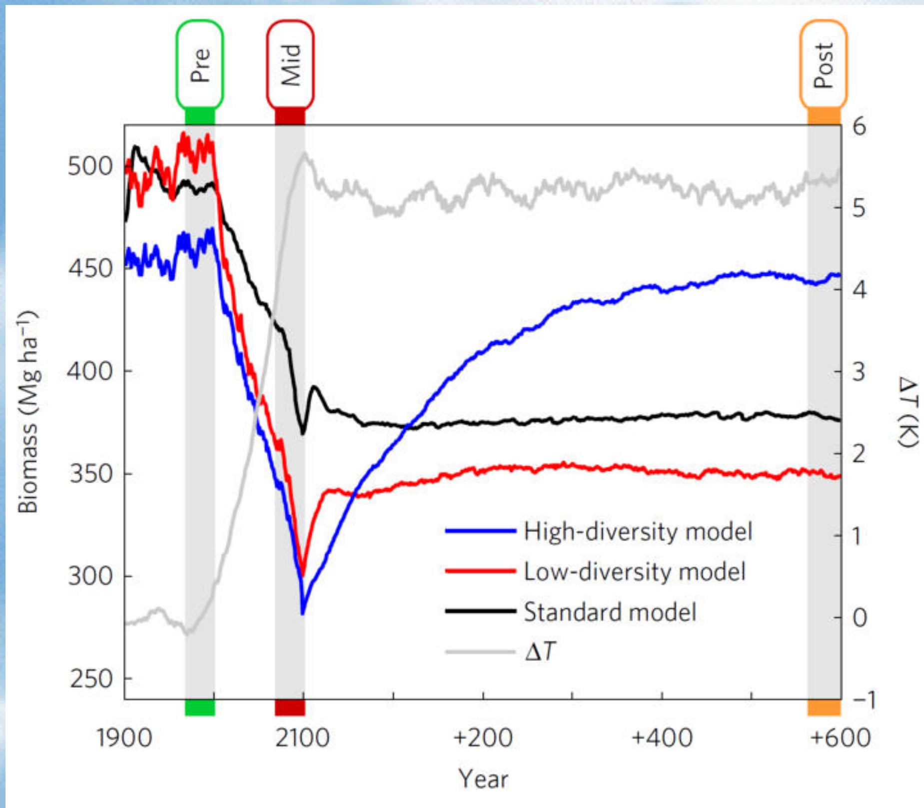

nature climate change

LETTERS

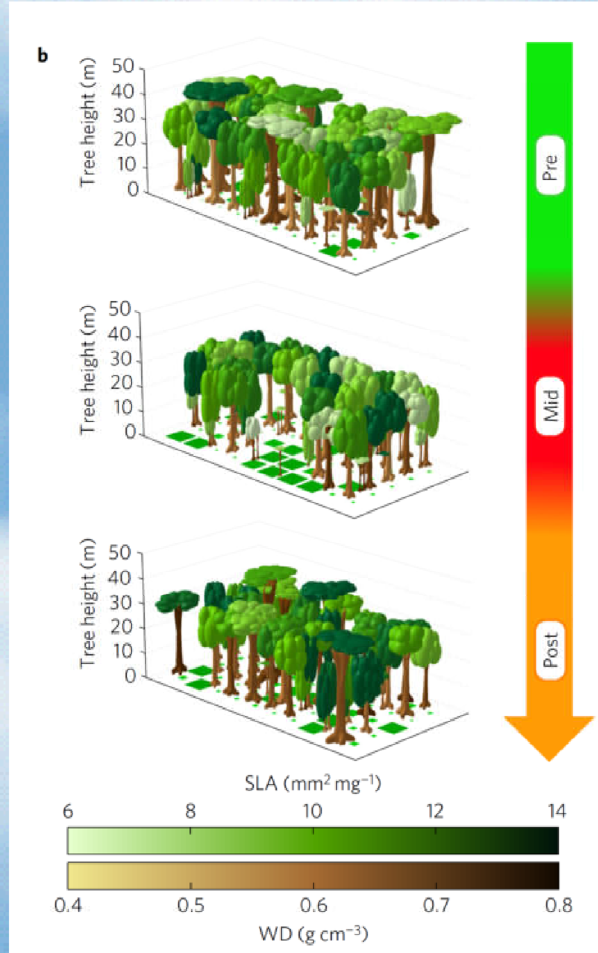
PUBLISHED ONLINE: 29 AUGUST 2016 | DOI: 10.1038/NCLIMATE3109

Resilience of Amazon forests emerges from plant trait diversity

Boris Sakschewski[1,2]*, Werner von Bloh[1,2], Alice Boit[1,2], Lourens Poorter[3], Marielos Peña-Claros[3], Jens Heinke[1,2], Jasmin Joshi[4] and Kirsten Thonicke[1,2]

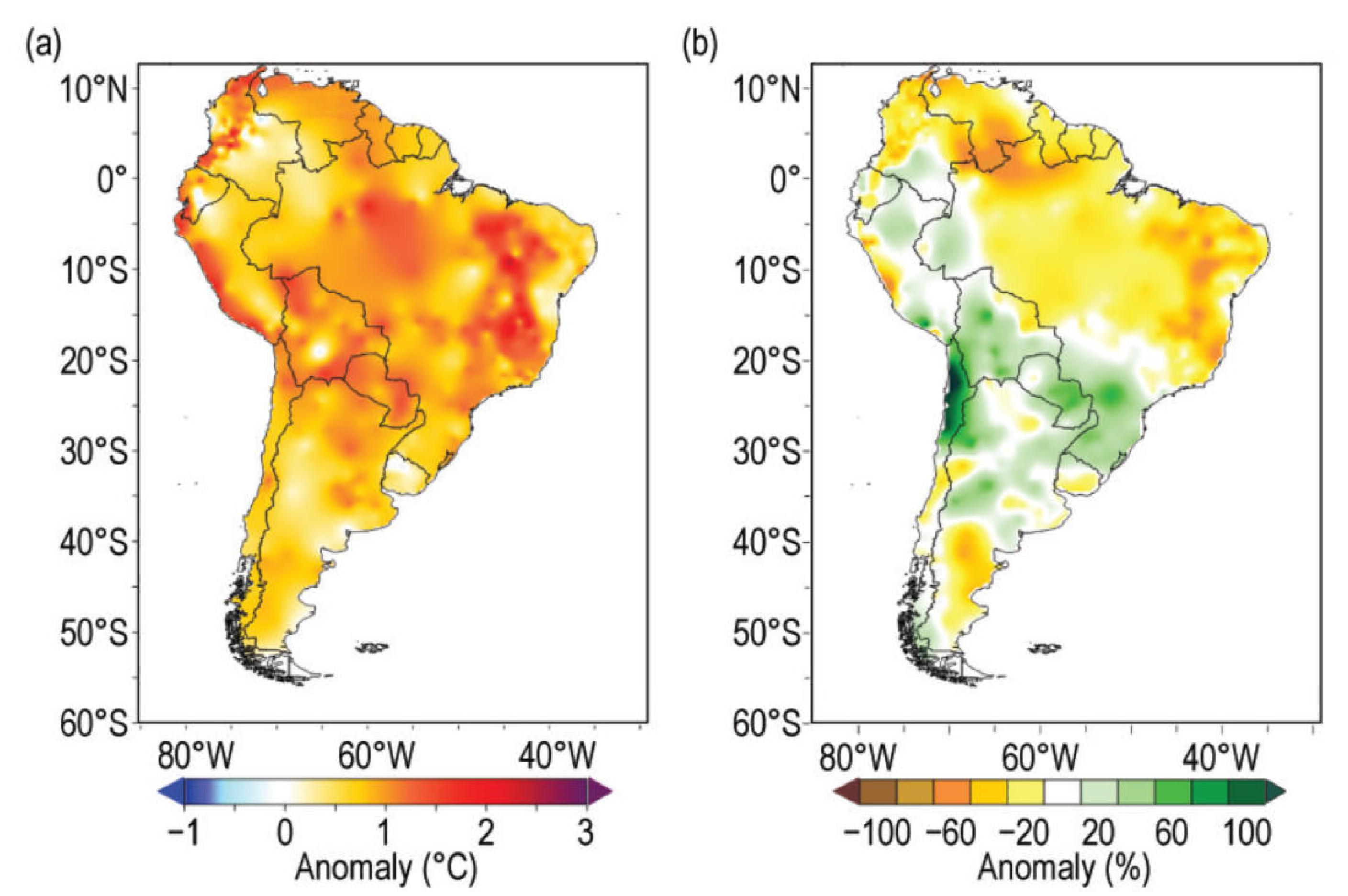


Annual biomass over 800 simulation years for 400 ha of Ecuadorian rainforest from three different versions of the vegetation model LPJmL under a severe climate change scenario (RCP 8.5 HadGEM2). 1*T*: annual temperature difference to the mean temperature of pre-impact time (1971–2000) in K.



Forest height structure recovers with biomass. Visualization of model output showing 0.5 ha of the 400 ha of Ecuadorian rainforest in a selected year during pre-, mid-, and post-impact time, respectively (top to bottom). Different crown (stem) colors denote different SLA (WD) values of individual trees.

South American (a) temperature anomalies (°C) and (b) precipitation anomalies

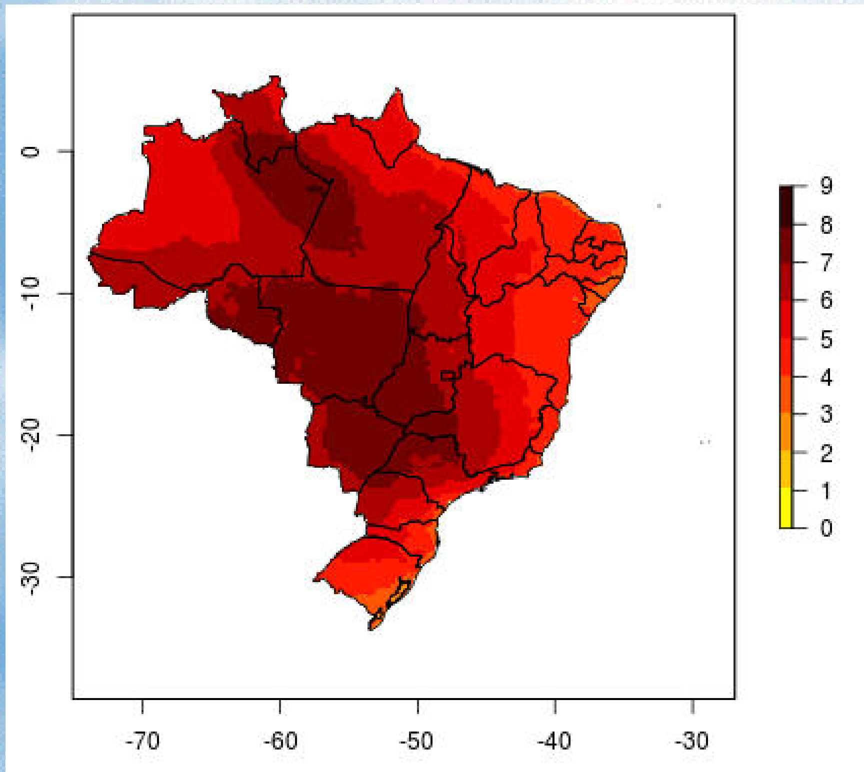


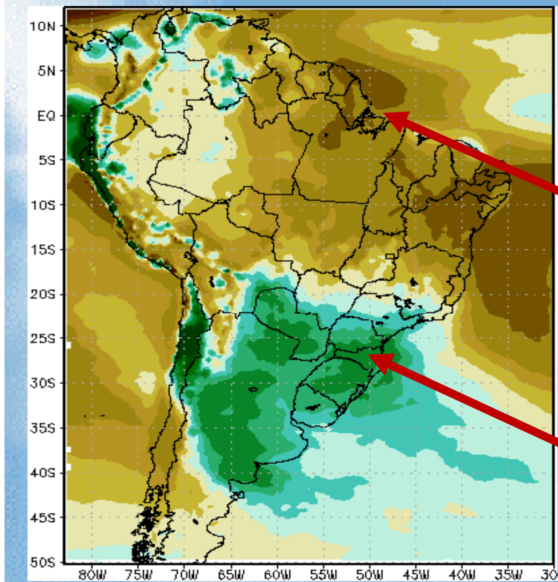
base period: 1981–2010.

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

Aumento médio de temperatura esperado para o Brasil 2071-2099

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

Áreas continentais se aquecem mais que áreas oceânicas

INPE, (RCP 8.5)

Climate models predict increasing temperature variability in poor countries

Relative changes of Standard Deviation of monthly temperature anomalies until the end of the 21st century. Averaged over climate models

austral summer [December, January, and February (DJF)],

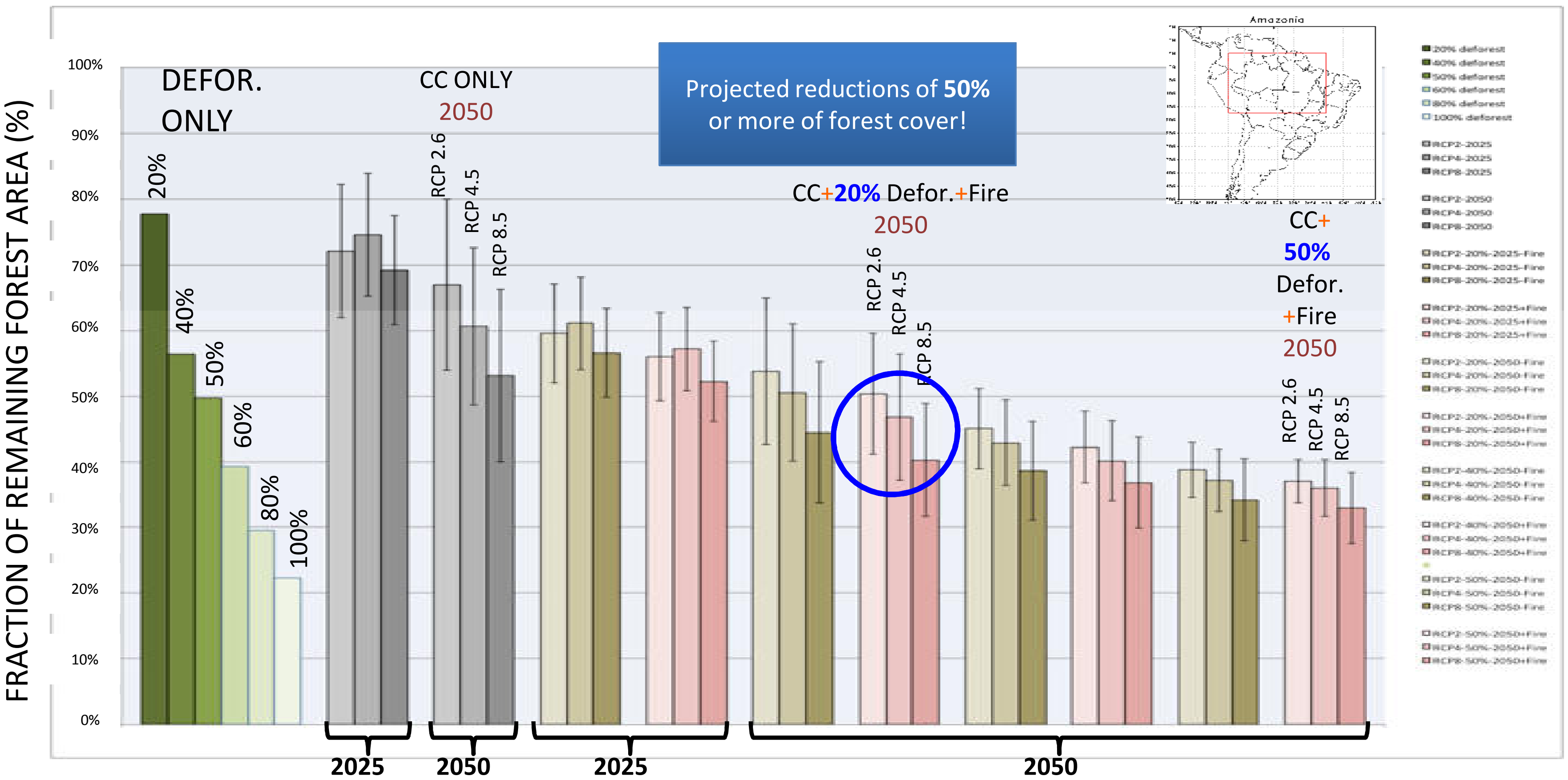
Bathiany et al., Sci. Adv. 2018;4: May 2018

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.

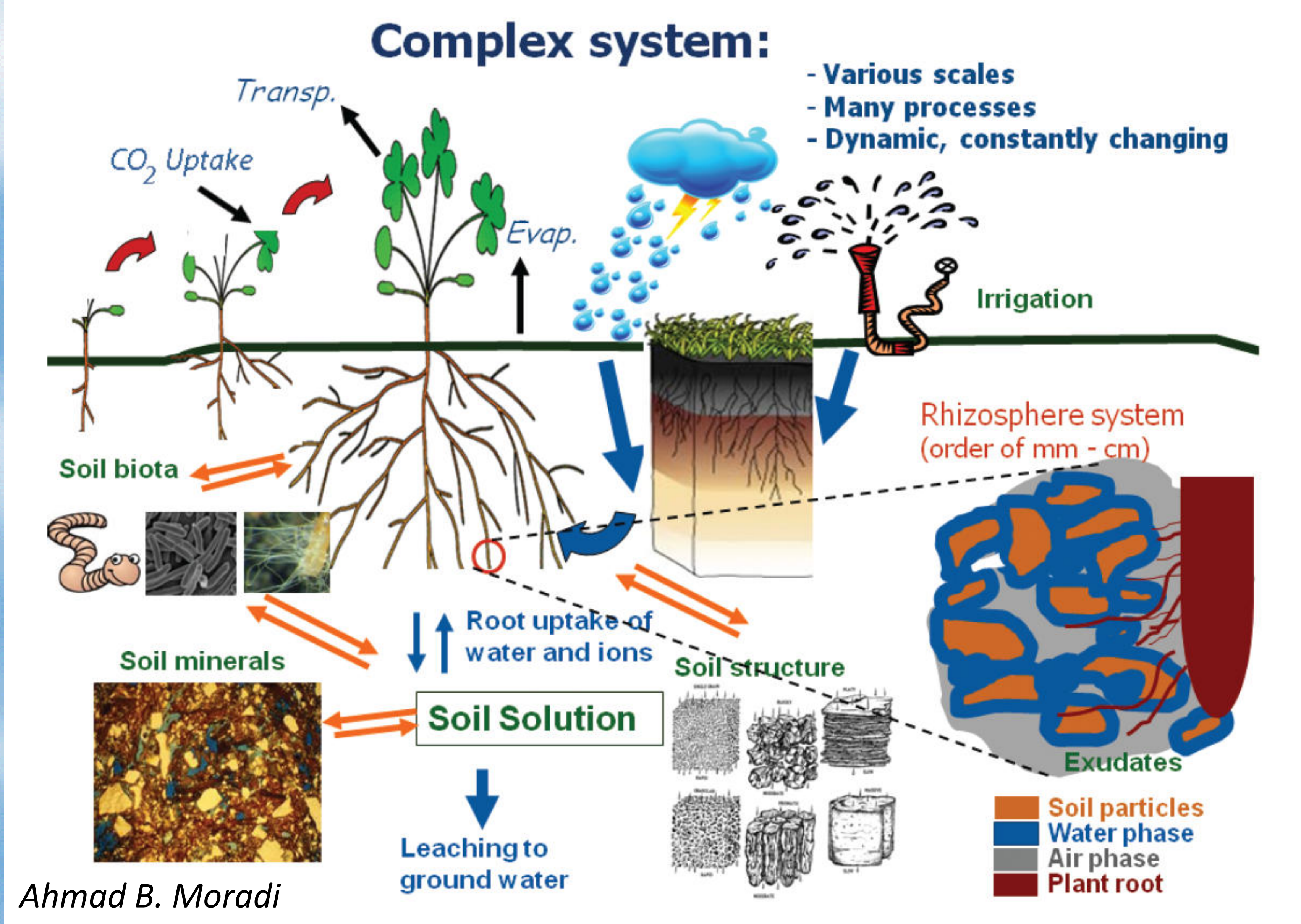
Nobre et al., PNAS, 2016

FRACTION OF THE REMAINING FOREST AREA FOR THE ENTIRE AMAZONIA
CLIMATE CHANGE PROJECTIONS – CMIP5 – 9 EARTH SYSTEM MODELS

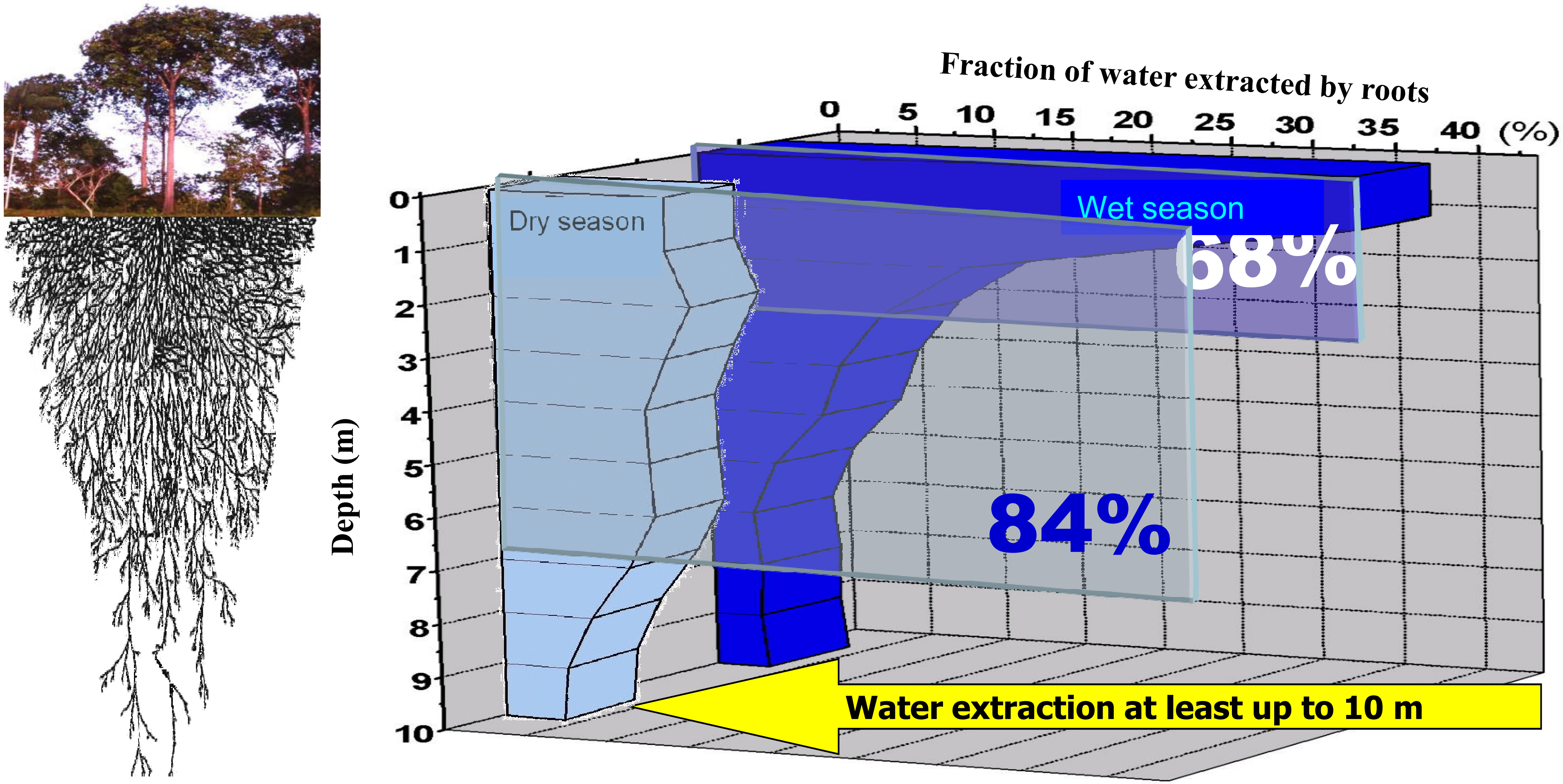


Nobre et al., 2016 PNAS

O complexo sistema solo-planta-atmosfera

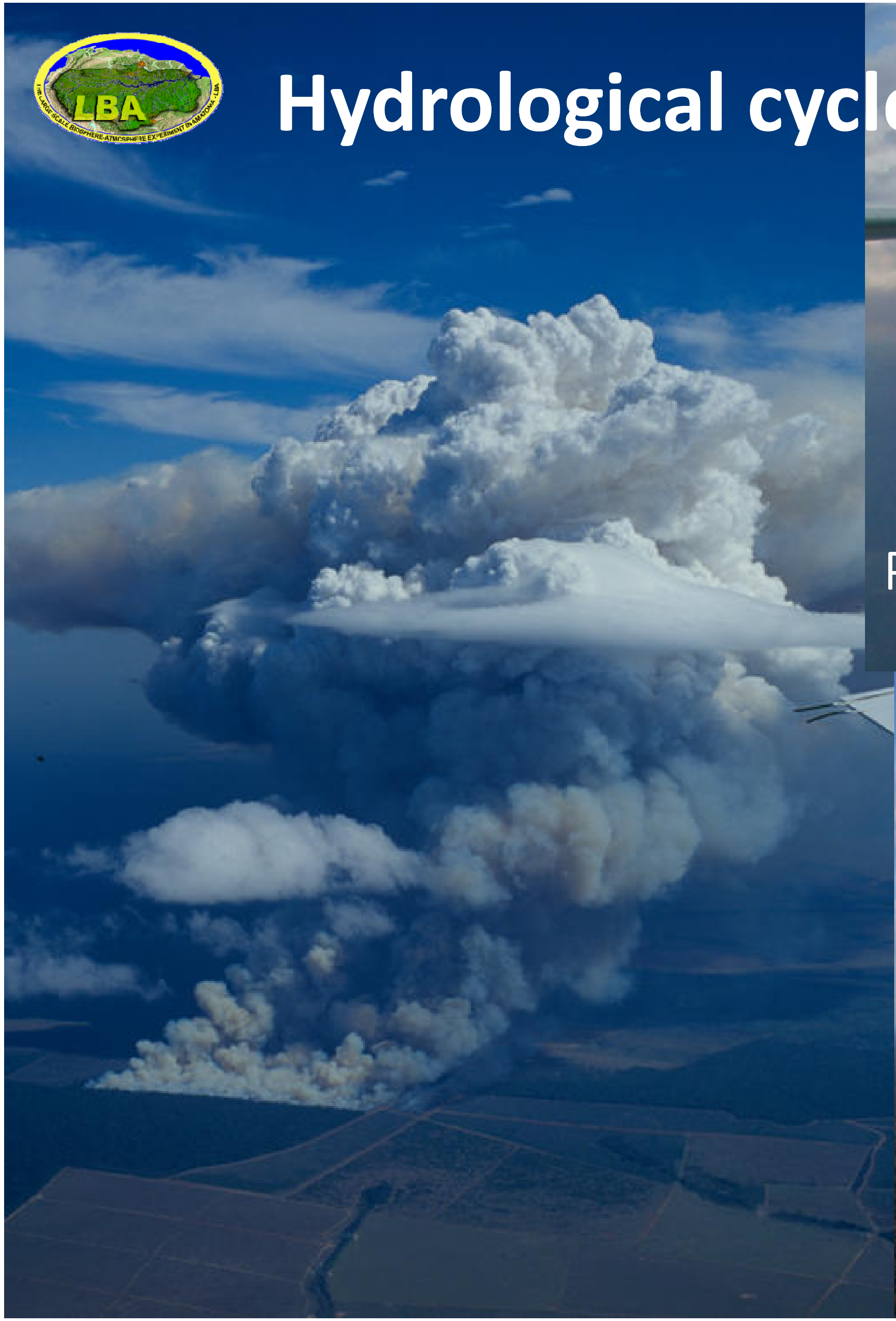


Ecological adaptation: Deep rooting in the Eastern Amazon

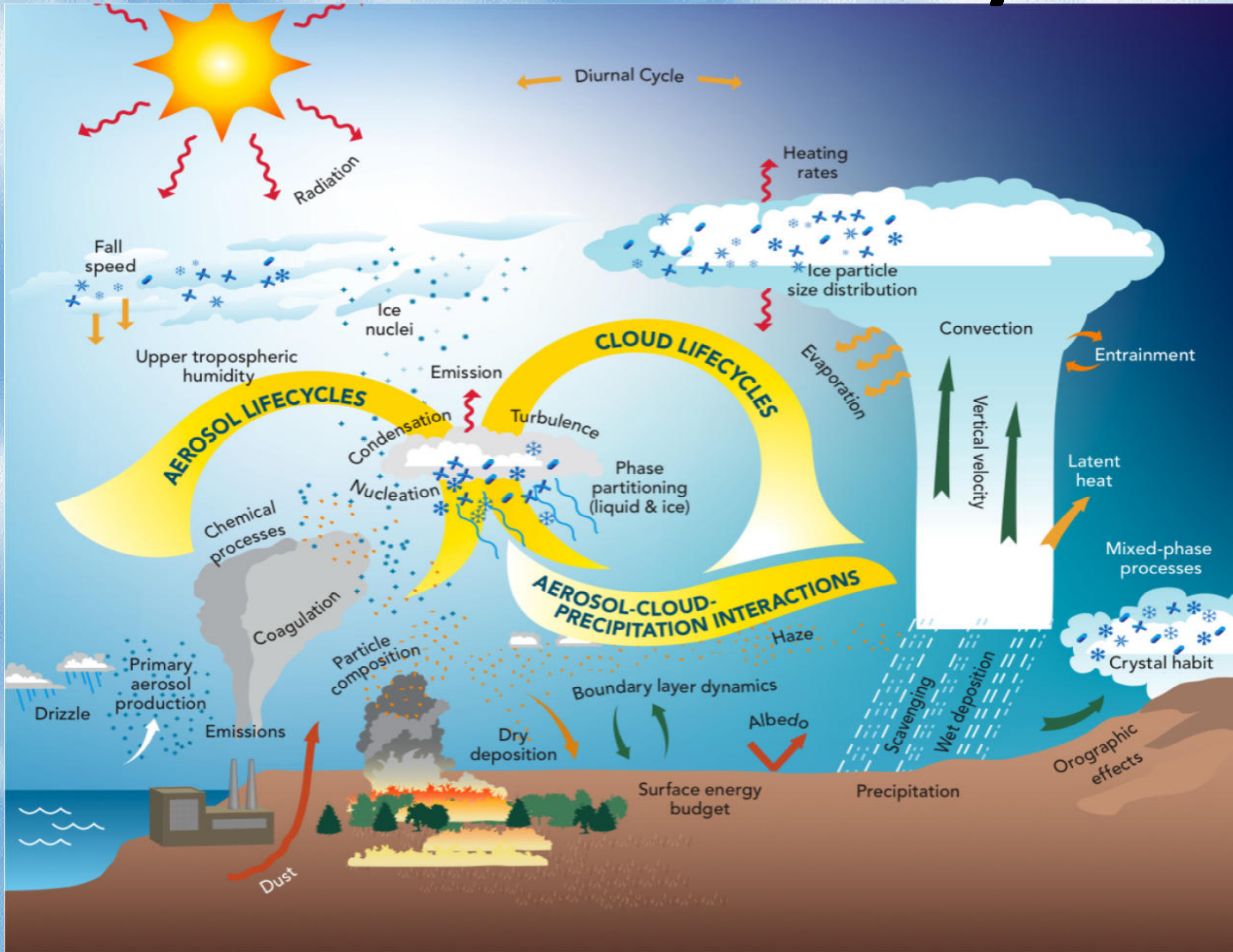


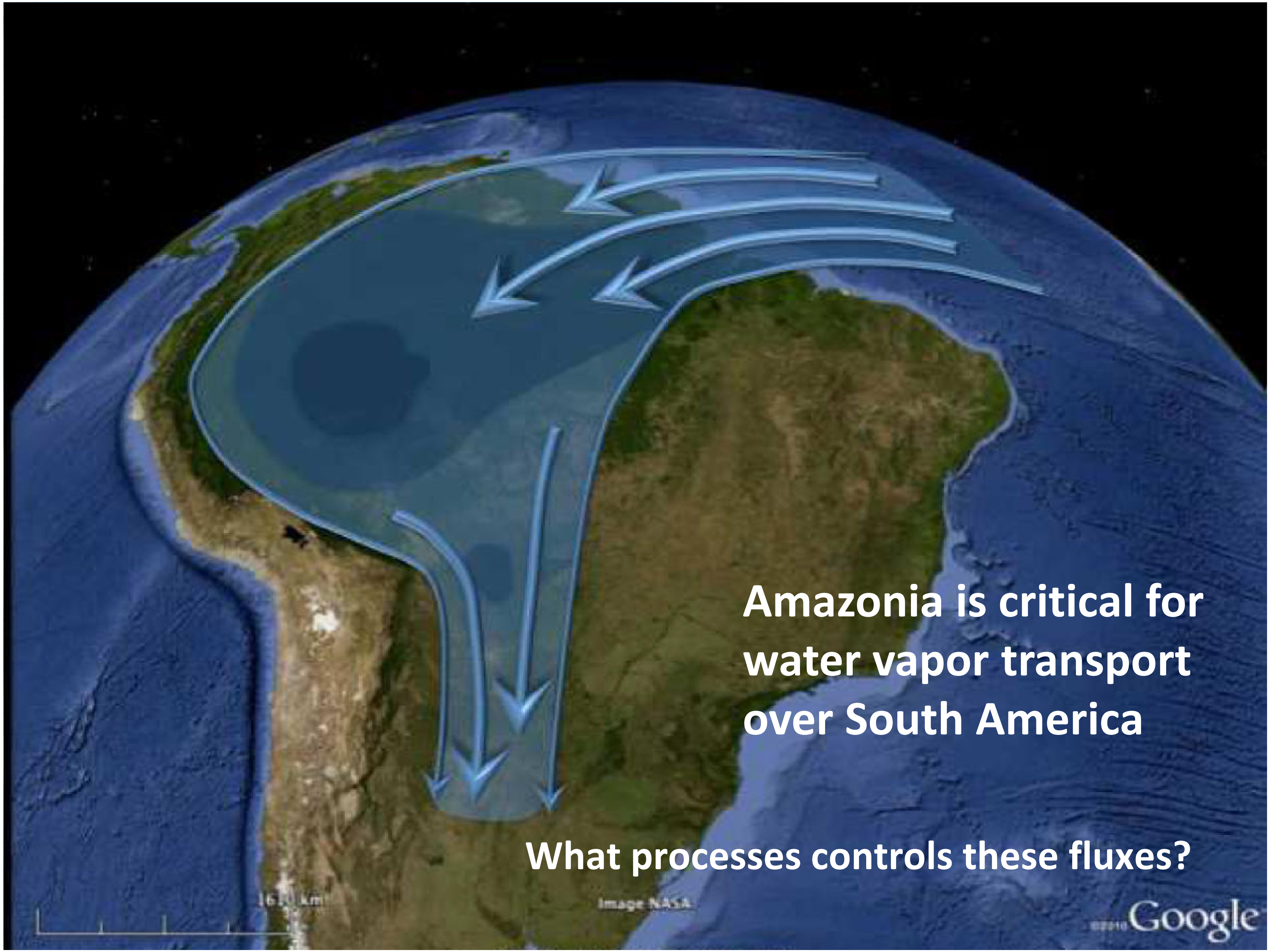
Source: Bruno et al., 2005 – Tropical forest data in Santarem km 83

Hydrological cycle critical for Amazonia

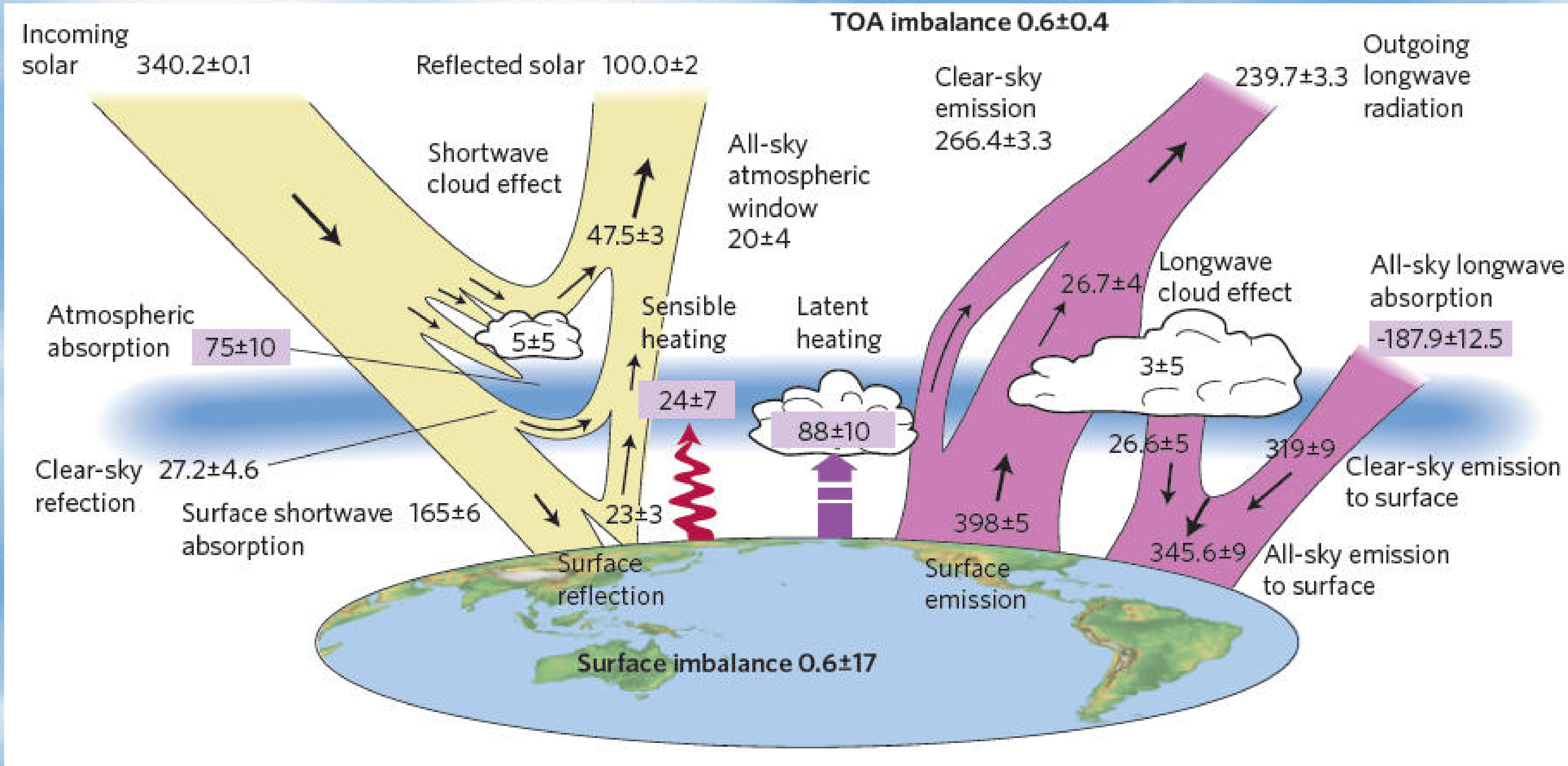


Aerosol and cloud lifecycles




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

Balanço de energia do sistema terrestre (w/m²)



Stephens, Nature 2012

THE AMAZON CLIMATE SYSTEM HAS BEEN OSCILLATING BETWEEN TWO EXTREMES IN THE LAST 13 YEARS

BASIN-WIDE OSCILLATION

DROUGHTS

3 events (1/200)
In the last 13 years

2005
2010
2015/16 (El Niño-related)

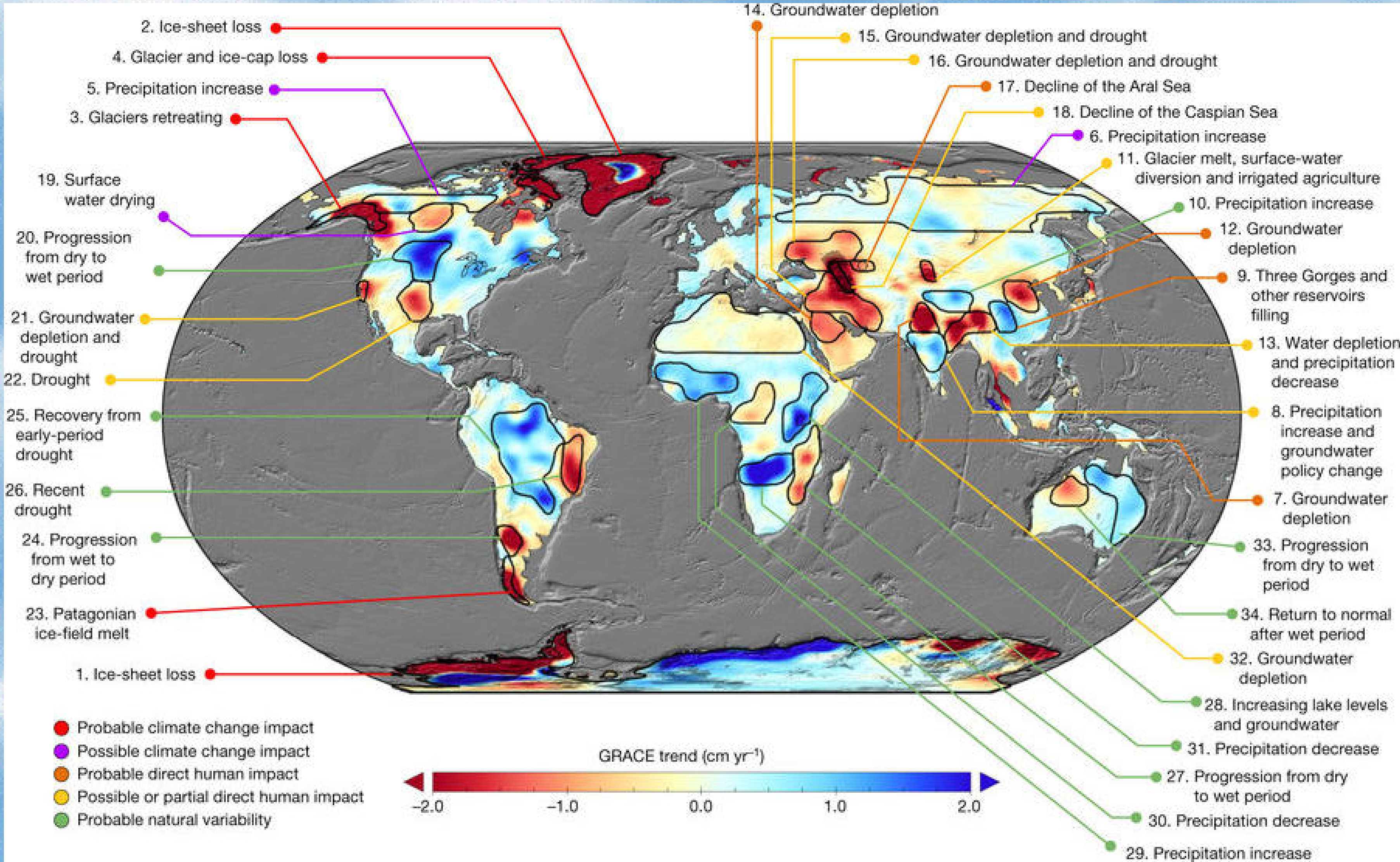
FLOODS

3 events (1/200)
In the last 13 years

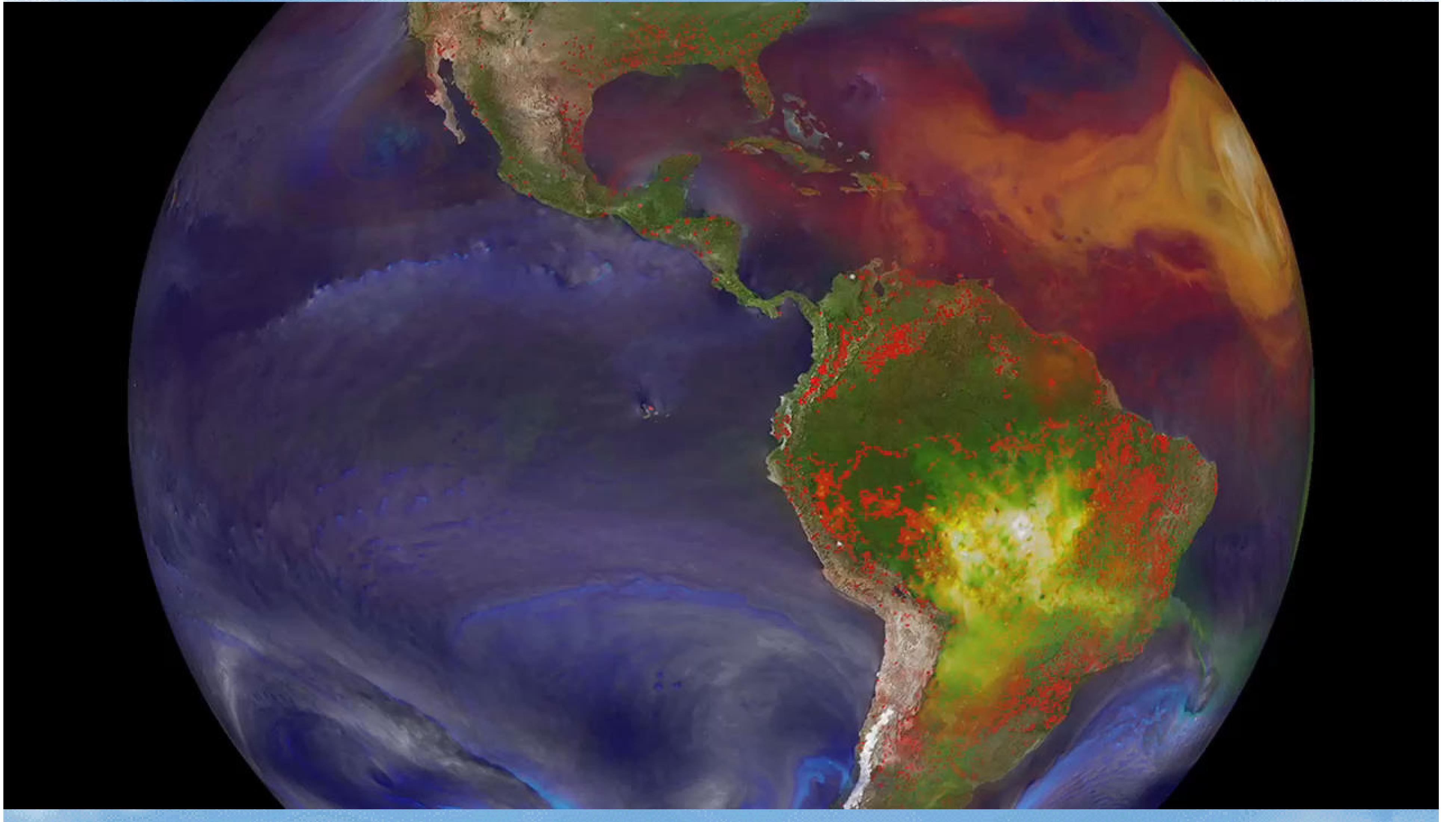
2009
2012
2014 (over SW Amazon)

Freshwater availability is changing worldwide

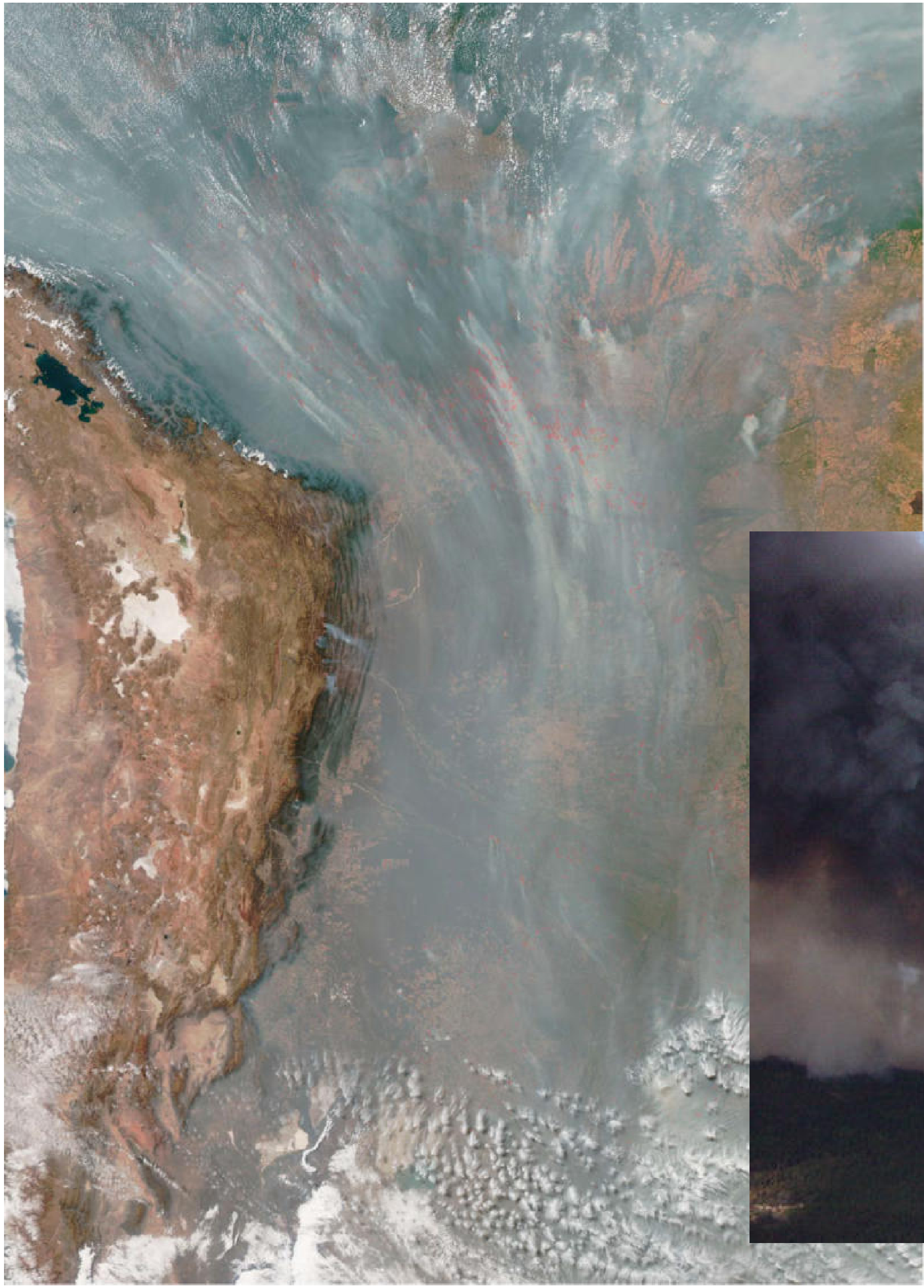
Emerging trends in global freshwater availability GRACE 2002-2016 (terrestrial water storage, Nature May 2018)



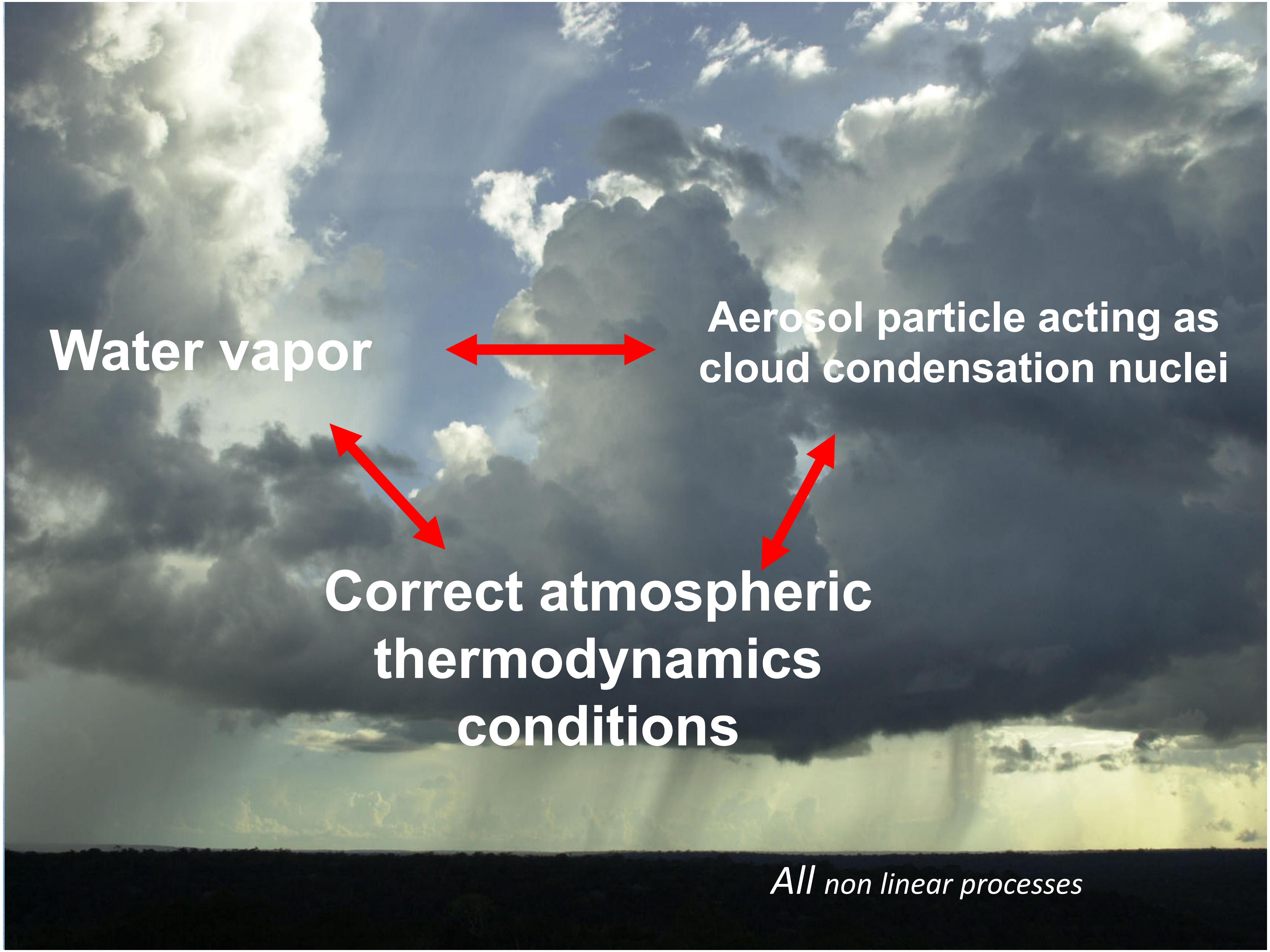
Partículas de aerossóis na atmosfera



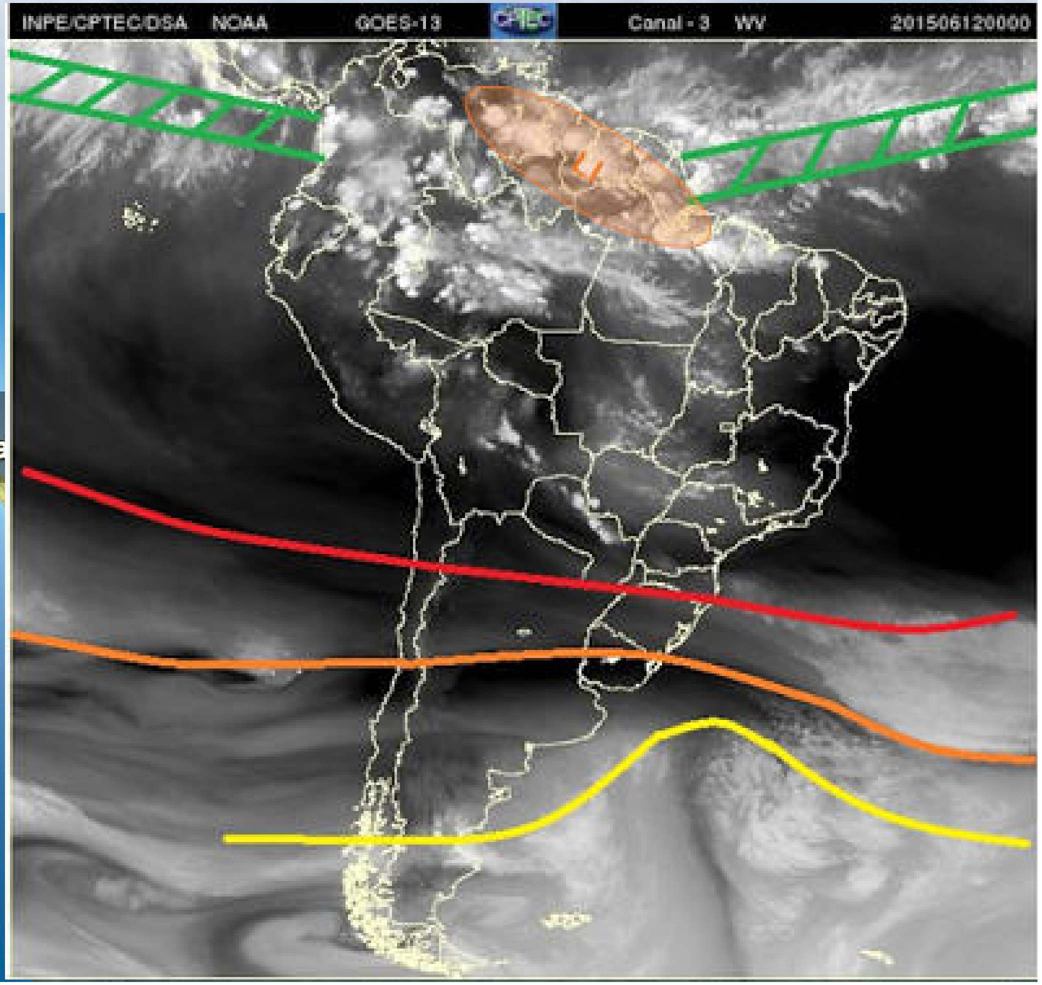
Tiny solid and liquid particles suspended in the atmosphere are called aerosols. Windblown dust, sea salts, volcanic ash, smoke from wildfires, and pollution from factories are all examples of aerosols. Depending upon their size, type, and location, aerosols can either cool the surface, or warm it. They can help clouds to form, or they can inhibit cloud formation. The simulation shows sea salt and dust swirl inside cyclones, sulfates stream from volcanoes, and carbon burst from fires (red dots) from May 2005 to May 2007, produced by the GEOS-5. In general, dust appears in shades of orange, sea salt appears in shades of blue, sulfates appear white, and carbon appears in shades of green. Such simulations allow scientists to better understand how these tiny particulates travel in the atmosphere and influence weather and climate.



Aerosol emissions make the high variability visible – it also applies to aerosol composition and the trace gases!


Water vapor
Aerosol particle acting as cloud condensation nuclei
Correct atmospheric thermodynamics conditions
All non linear processes

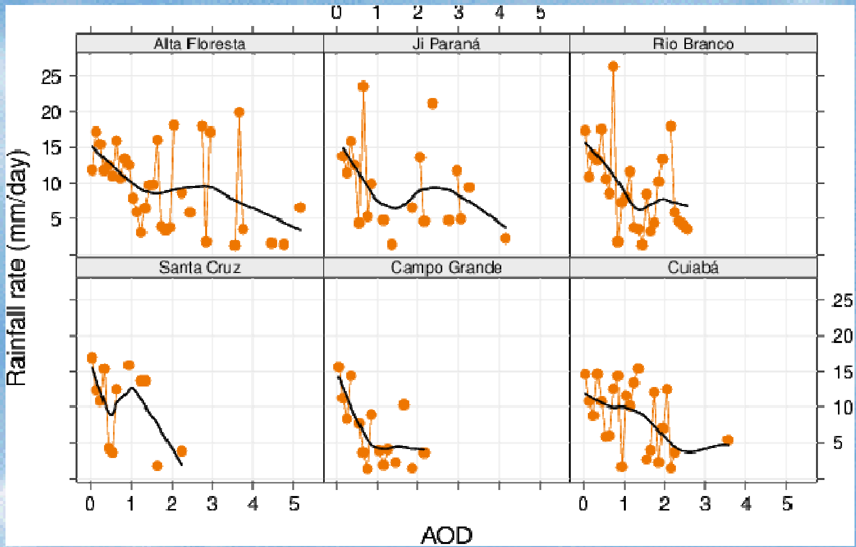
Convective clouds: Key for radiation balance and precipitation



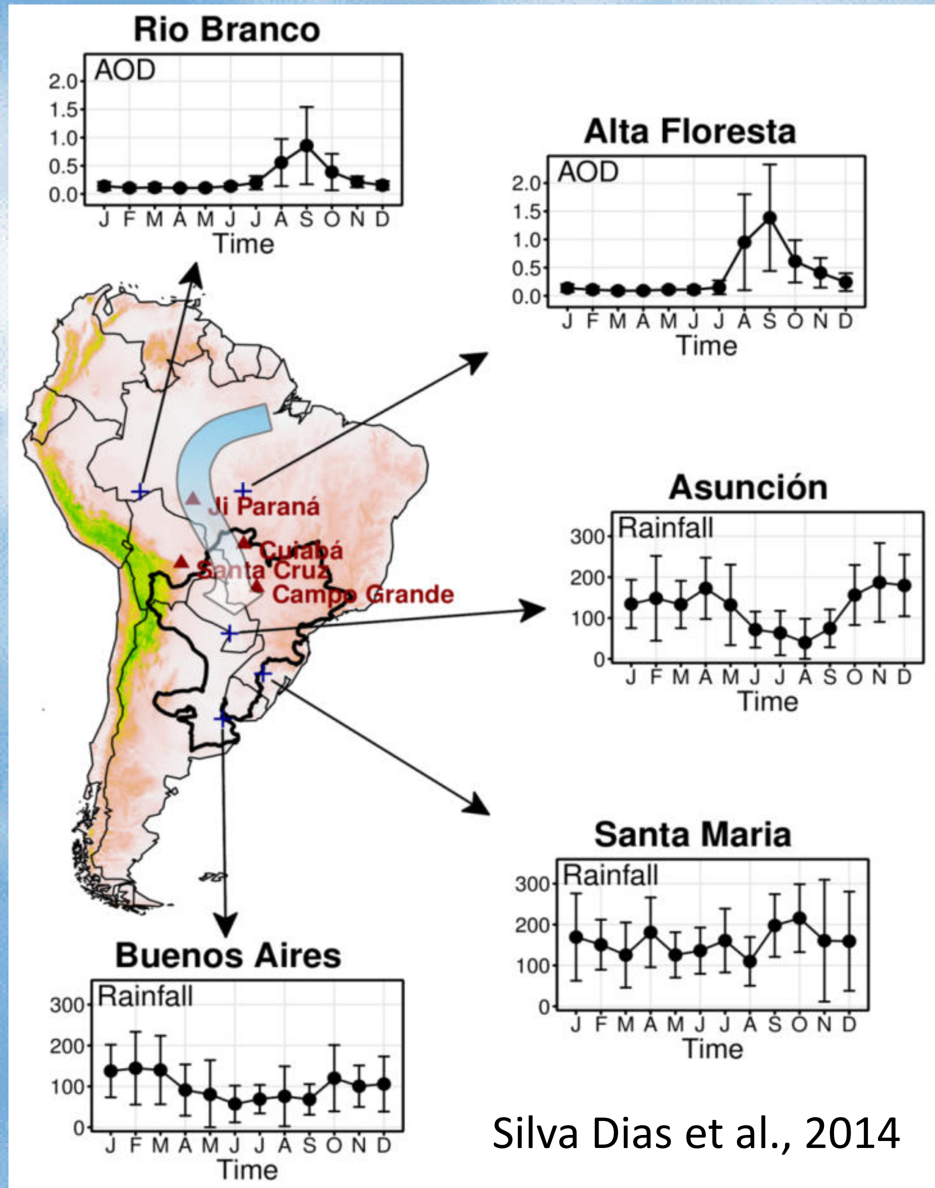
Relationship between aerosols and precipitation in the La Plata Basin

AERONET (Aerossols) + TRMM (Precipitation) + BRAMS (simulations)

Reduction in precipitation with increase in aerosols



BRAMS: Simulations with cloud microphysics confirm the measurements



Silva Dias et al., 2014

Regional dry-season climate changes due to three decades of Amazonian deforestation

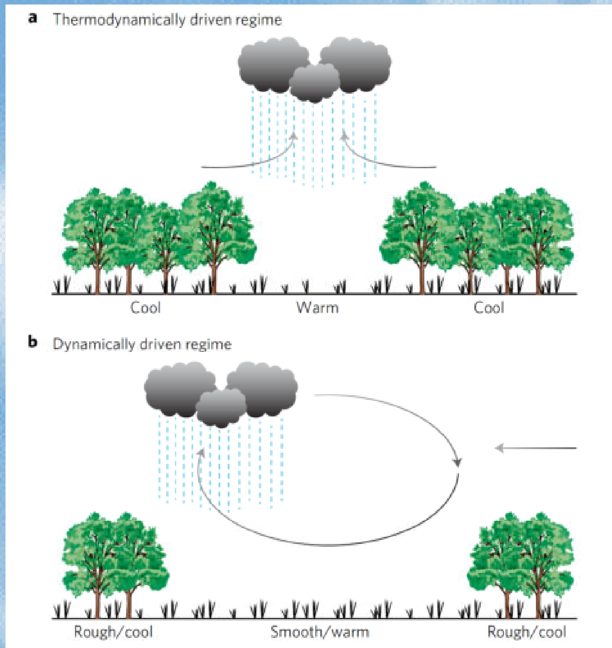
news & views

BIOSPHERE–ATMOSPHERE INTERACTIONS

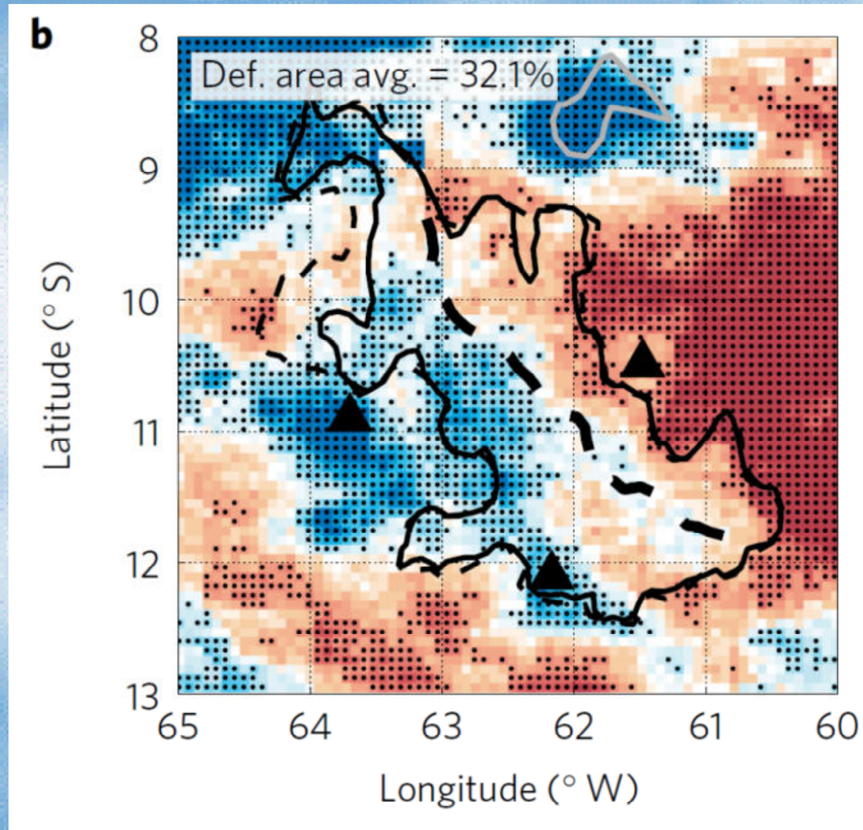
Deforestation size influences rainfall

Changes to the land surface, such as land clearing and logging of forest areas, impacts moisture cycling. Now a shift from small-scale to large-scale deforestation in the southern Amazon is found to modify the mechanisms and patterns of regional precipitation.

Jeffrey Q. Chambers and Paulo Artaxo



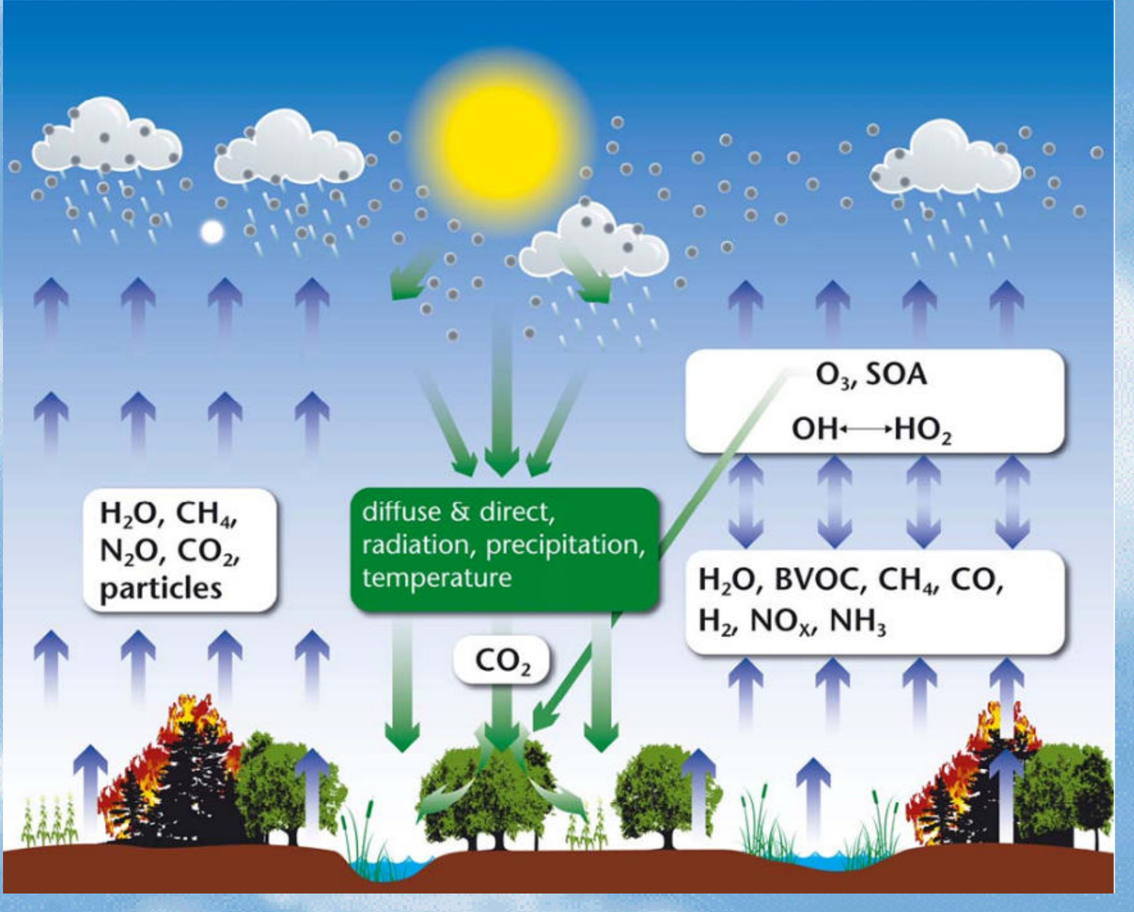
Transition in the dominant convective regime with increasing scales of deforestation



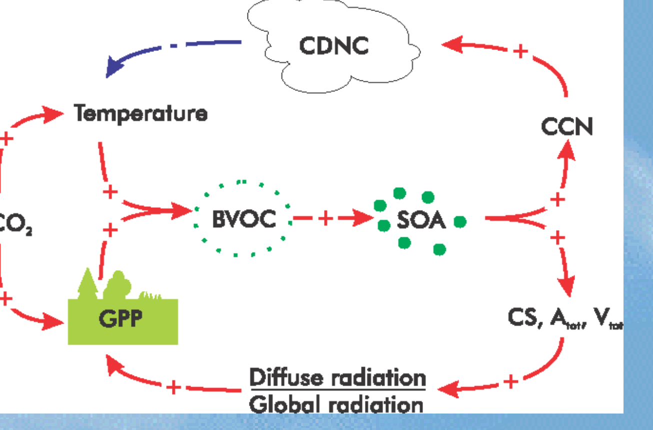
Emergence of the southeast–northwest cloud and precipitation 'dipoles' with increasing deforestation in Rondônia

Jaya Khanna Nature climate change 2017

Conceptual overview of terrestrial carbon cycle – chemistry – climate interactions

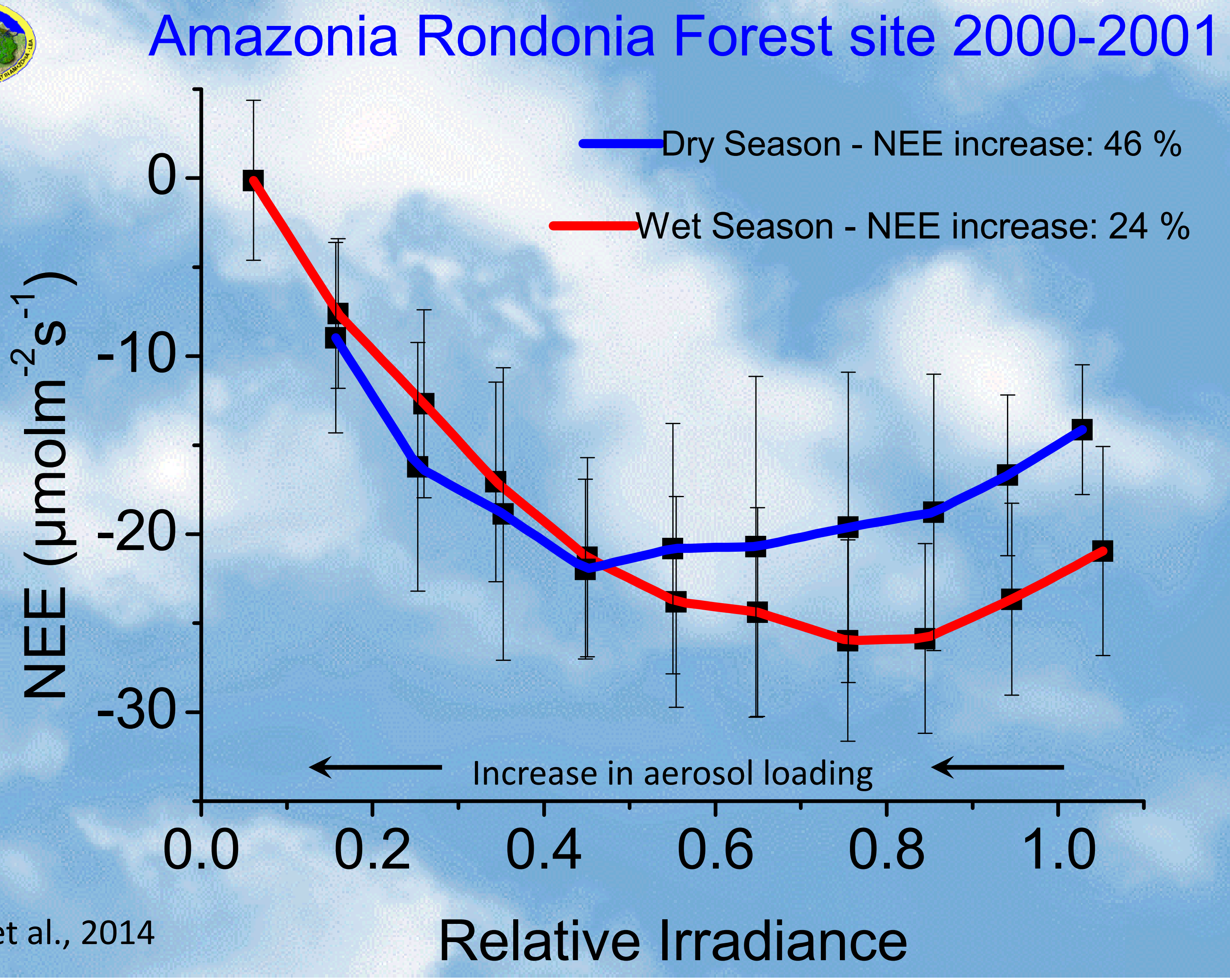


Arneth et al., 2011



Kulmala et al, 2013

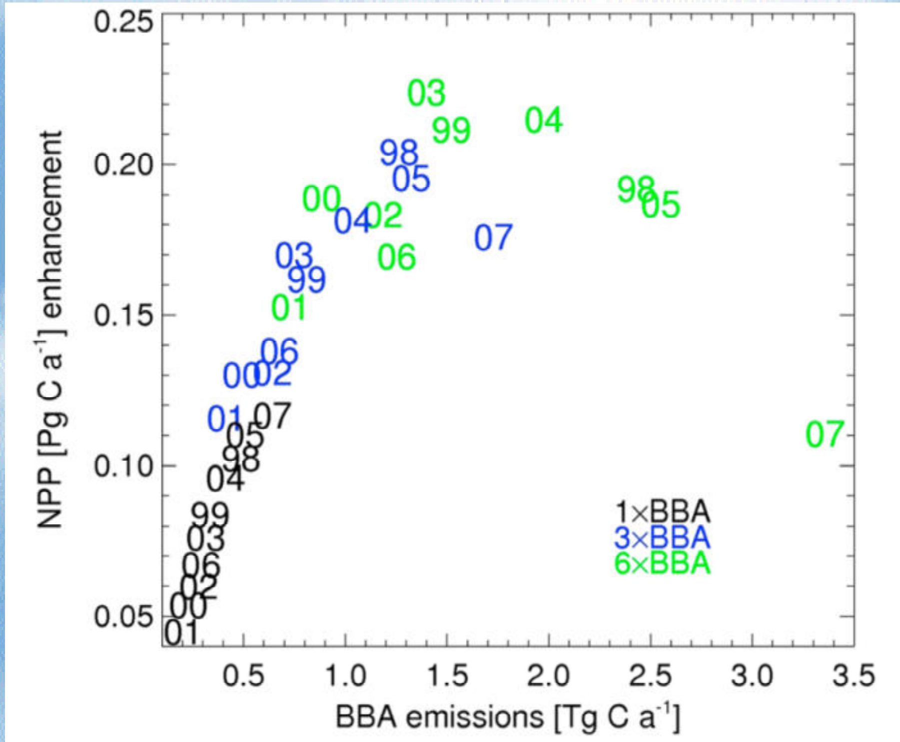
Strong effects of aerosols on carbon uptake in Amazonia



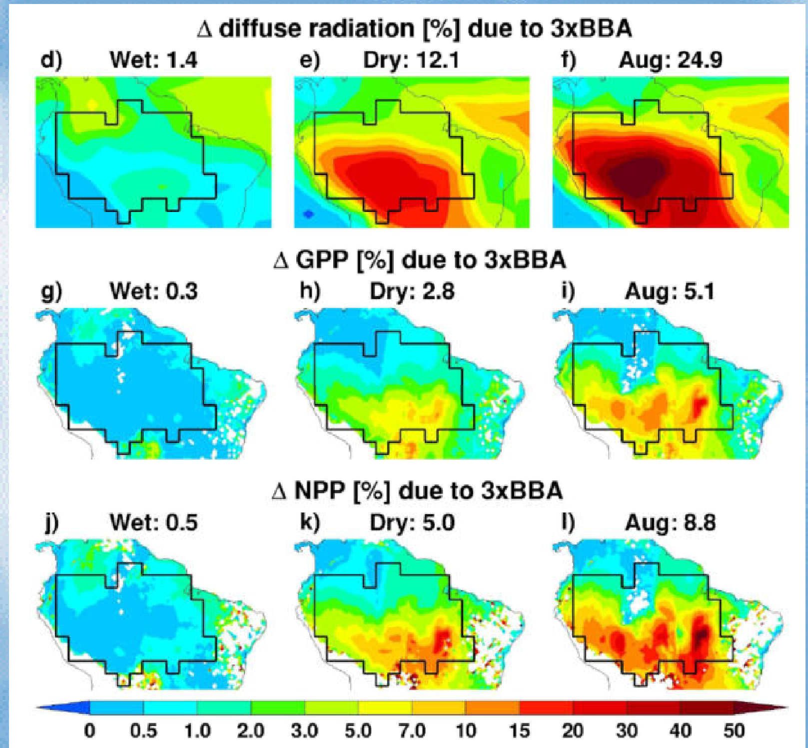
Cirino et al., 2014

Fires increase Amazon forest productivity through increases in diffuse radiation

Rap et al., 2015



Amazon basin annual mean NPP enhancement caused by BBA as a function of BBA emissions (black: standard BBA emissions; blue: 3 × BBA emissions; and green: 6 × BBA emissions), for each year during

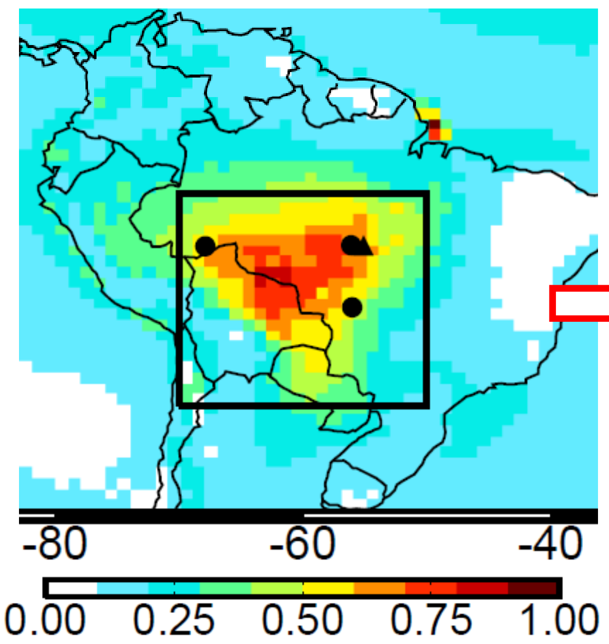


Modeled 1998–2007 mean percentage changes in (a–c) diffuse radiation, (g–i) GPP, and (j–l) NPP during the wet (defined here as December to May) season, dry (June to November) season, and August due to BBA emissions.

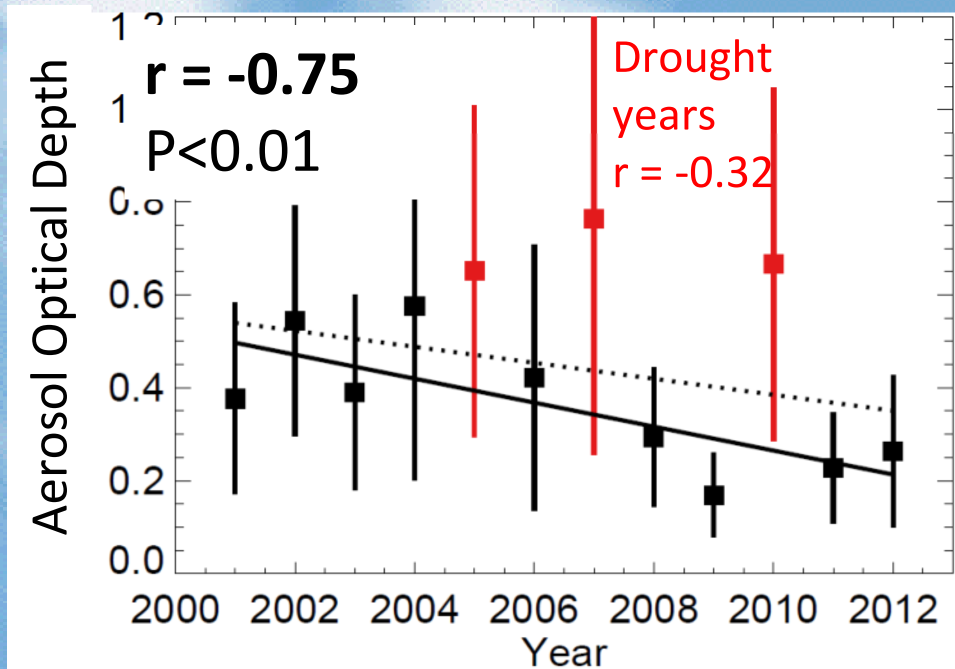
LETTERS
PUBLISHED ONLINE: 16 SEPTEMBER 2015 | DOI: 10.1038/NGEO2535
nature geoscience

Air quality and human health improvements from reductions in deforestation-related fire in Brazil

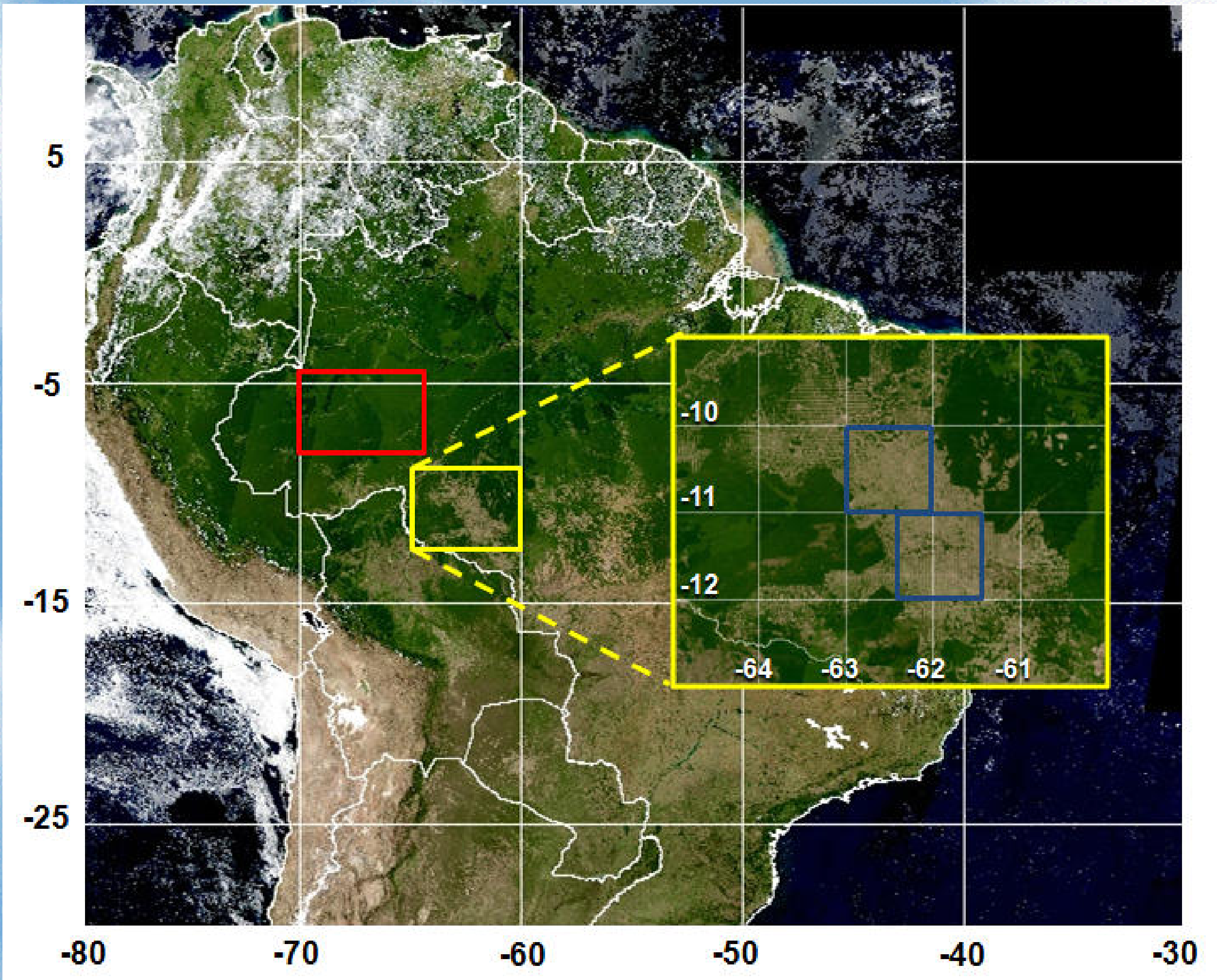
C. L. Reddington[1], E. W. Butt[1], D. A. Ridley[2], P. Artaxo[3], W. T. Morgan[4], H. Coe[4] and D. V. Spracklen[1]*



Dry season mean AOD retrieved by MODIS



⇒Reduction in PM2.5 may be preventing roughly 1,700 premature adult deaths annually across South America.



Mean Diurnal Radiative Forcing due to change in surface albedo: -8.0 ± 0.9 W/m²

Mean Diurnal Aerosol Forcing Efficiency:

Forest: -22.5 + 1.4 W/m²

Cerrado: -16.6 ± 1.7 W/m²

Land-use change radiative forcing. Forested areas are selected in red and deforested areas are selected in blue.

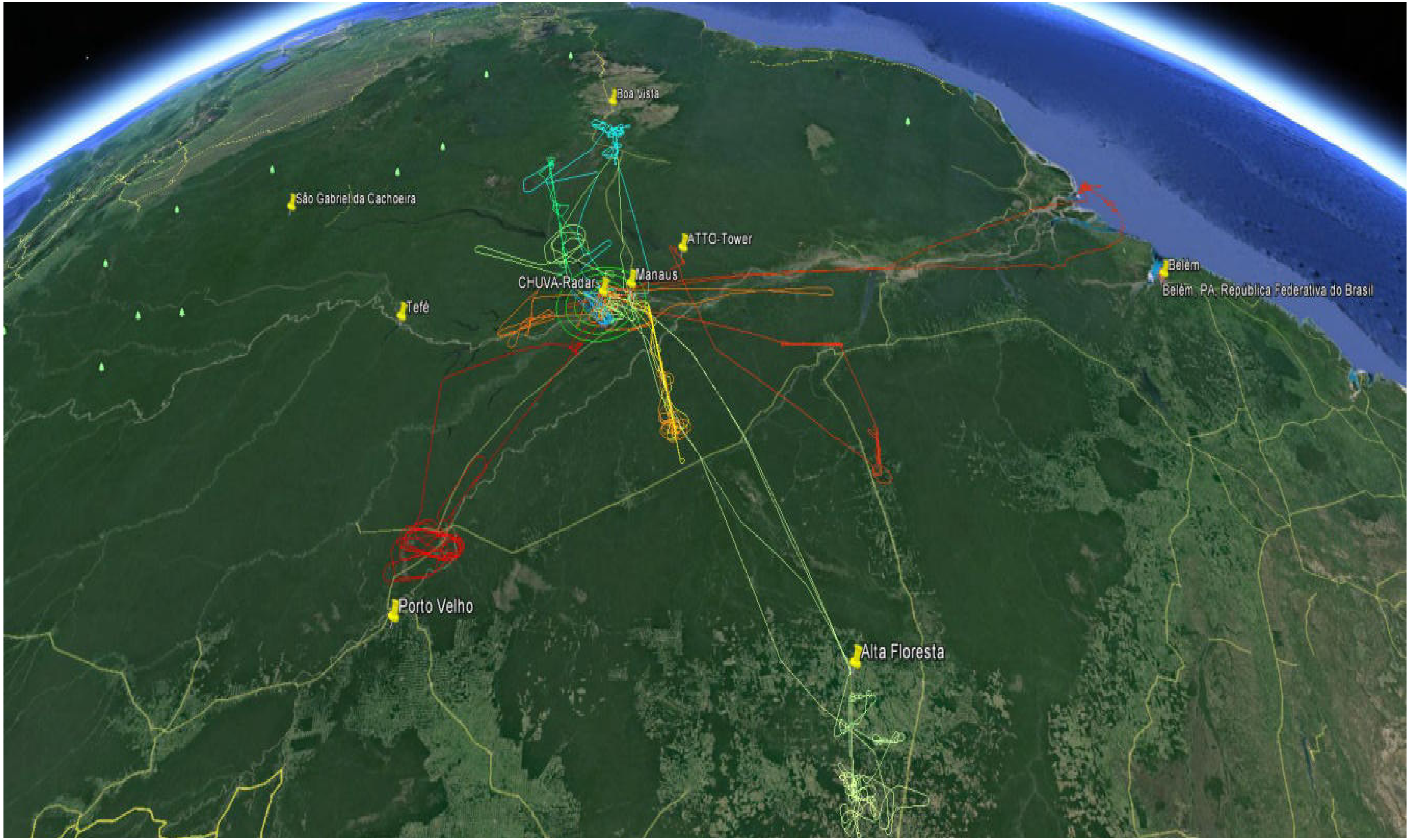
Elisa Sena results, 2011

GoAmazon Large scale measurements

G5 HALO plane - "High Altitude and Long Range Research Aircraft".

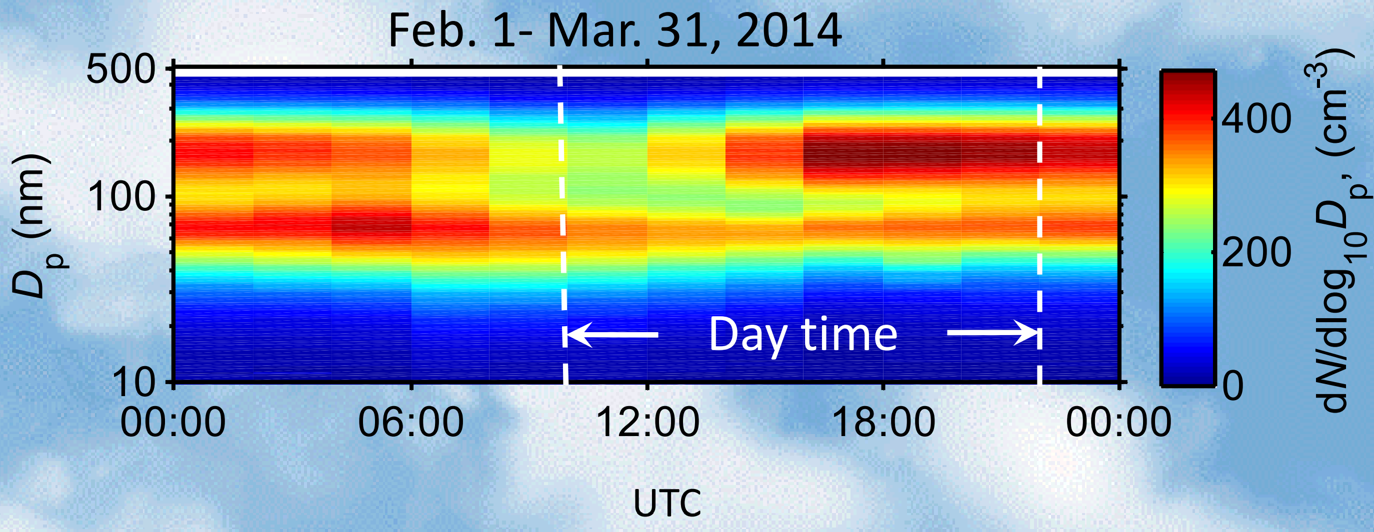
DoE G1 plane in two campaigns at wet and dry seasons

ACRIDICON Flights G5-HALO plane dry season 2014

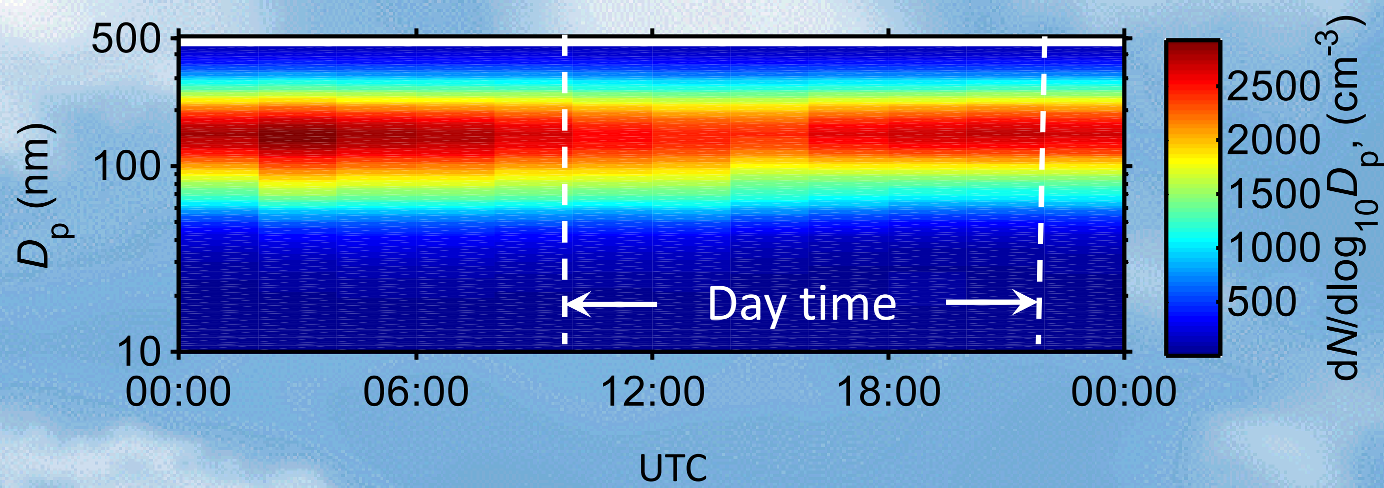


How particles are produced in Amazonia?

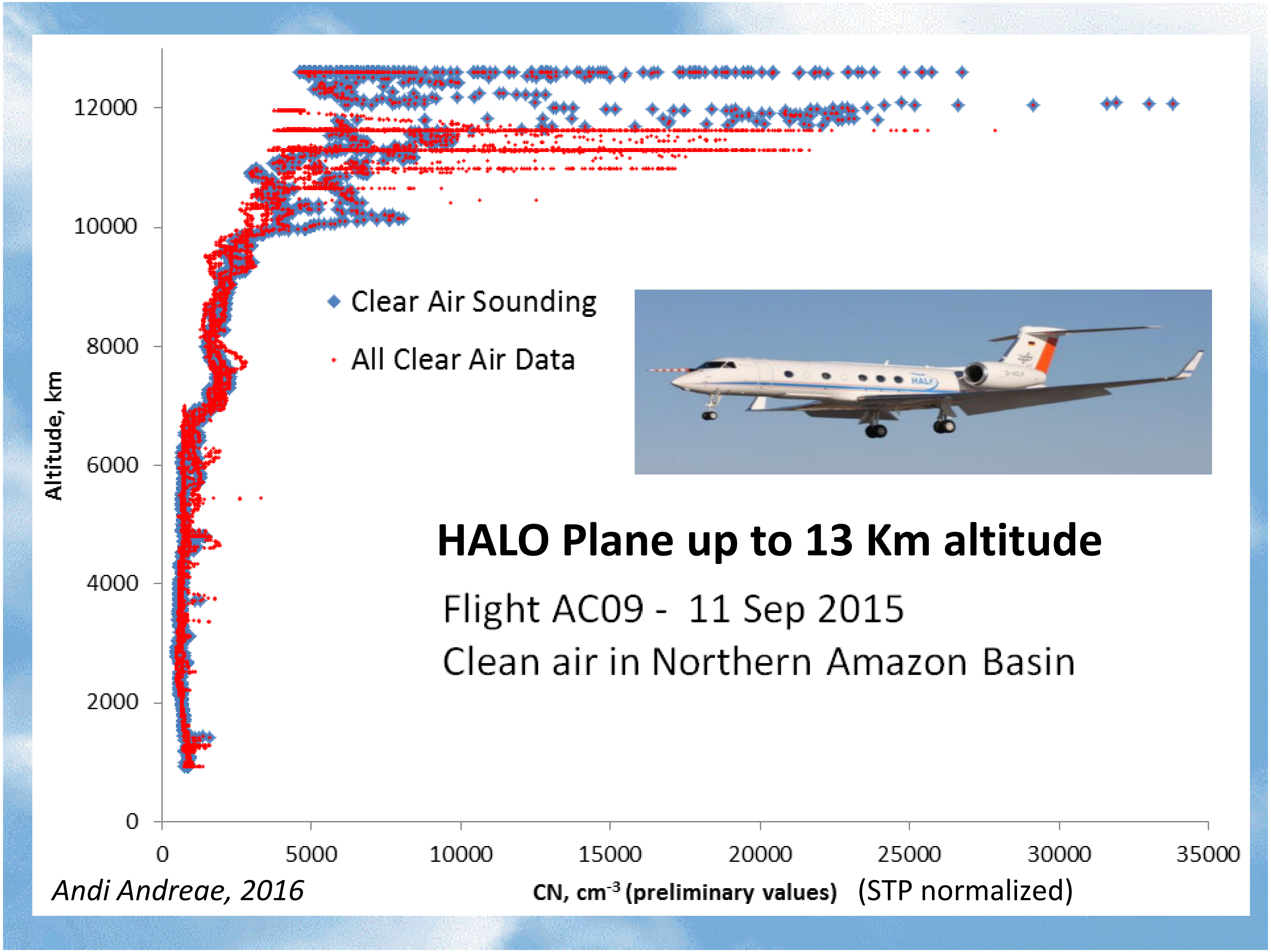
T0 site (ATTO)
(All data)
N: ~320 cm^{-3}



T0 site (ATTO)
(dry season)
N: ~3100 cm^{-3}

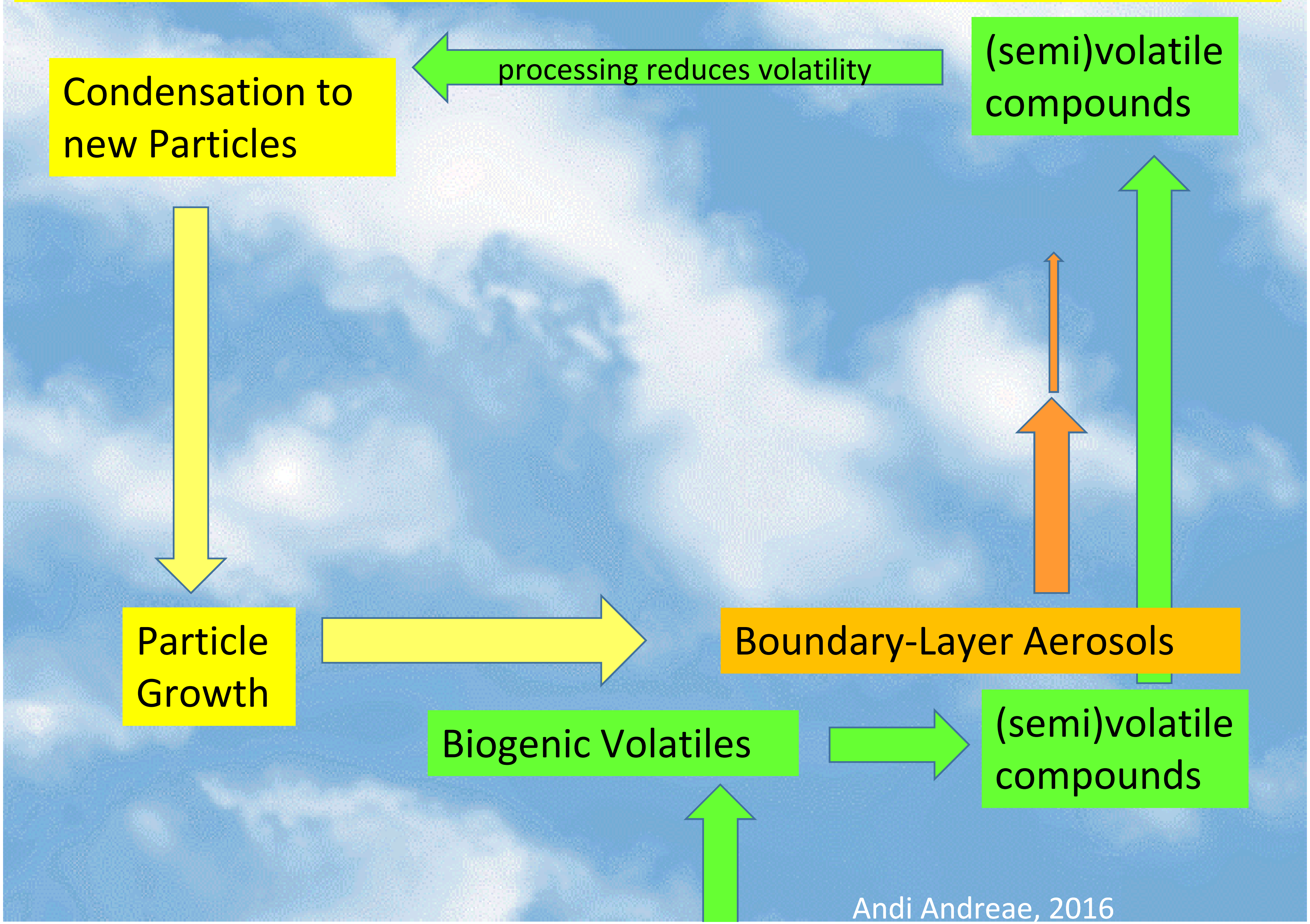


It rains a lot. Removal very high. How the particles are formed?

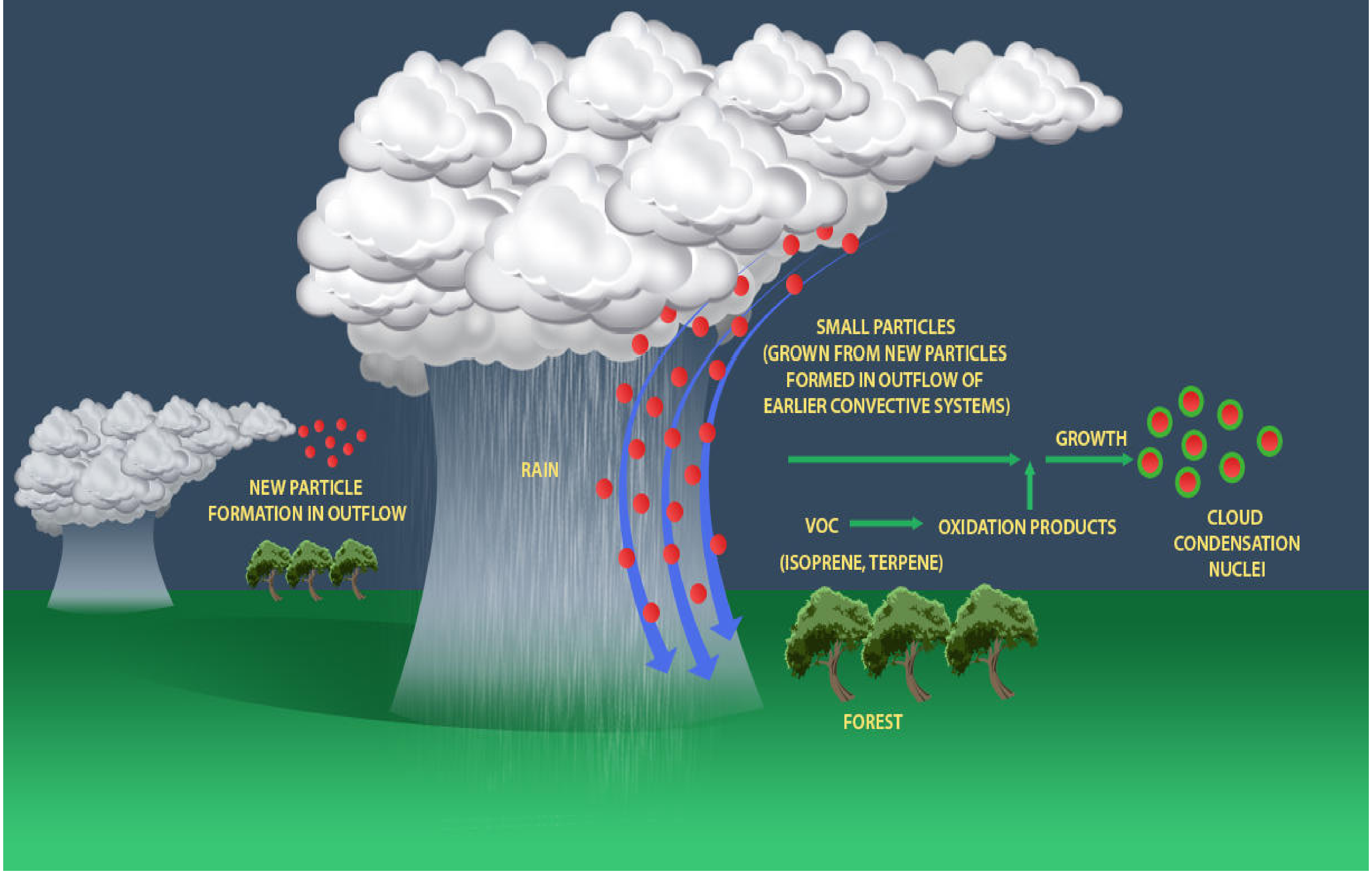


HALO Plane up to 13 Km altitude
Flight AC09 - 11 Sep 2015
Clean air in Northern Amazon Basin
Clear Air Sounding
All Clear Air Data
Altitude, km
0
2000
4000
6000
8000
10000
12000
0
5000
10000
15000
20000
25000
30000
35000
CN, cm-3 (preliminary values) (STP normalized)
Andi Andreae, 2016

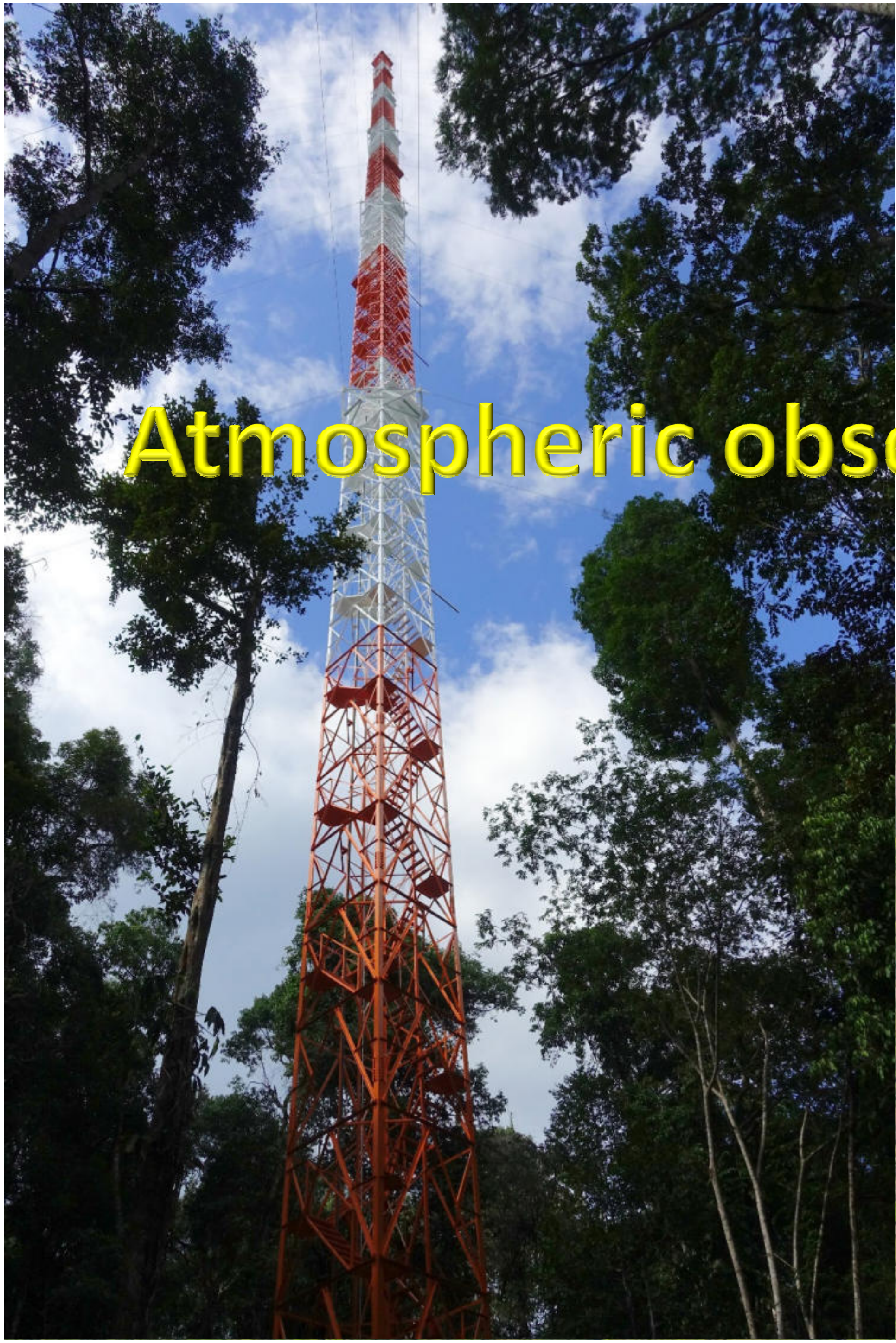
Biogenic organic aerosol formation at low H_2SO_4 happens in UT!

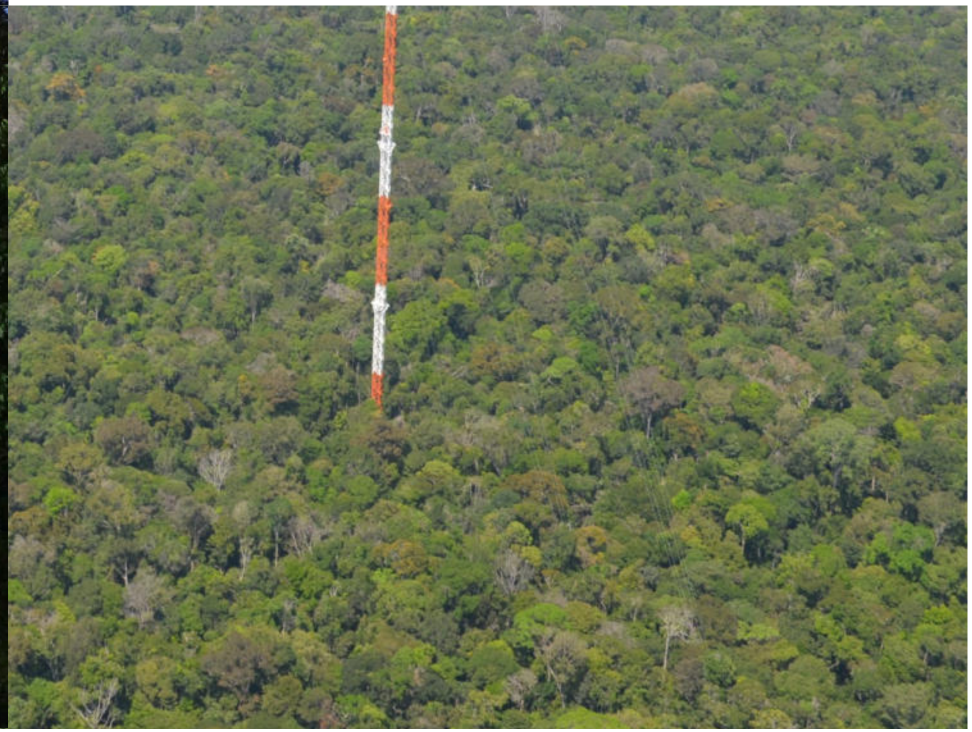


Clouds as active aerosol processors in the atmosphere

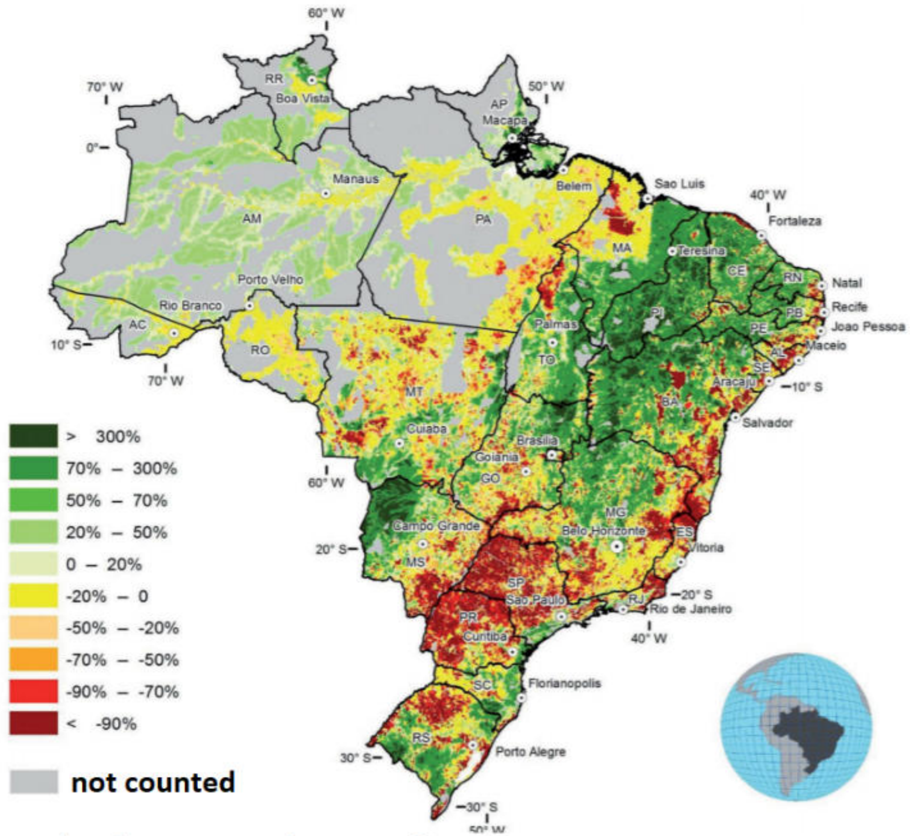


Atmospheric observations at ATTO



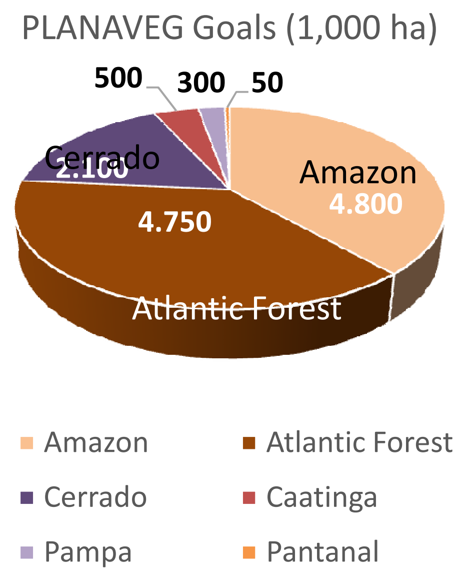


Brazil's NDC to the Paris Agreement calls for ecosystem restoration of 12.5 million hectares



Levels of Forest Code Compliance

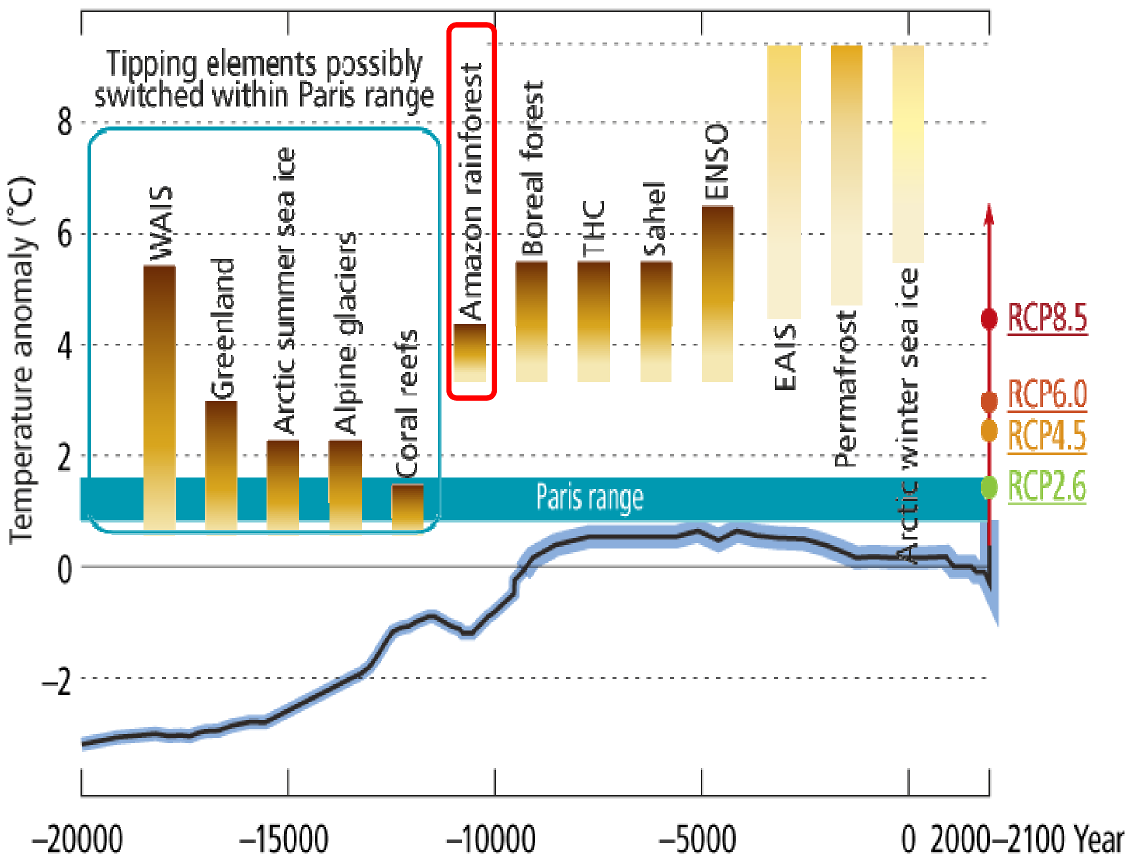
Percent difference between the remaining area of native vegetation and the area required to comply with the Forest Code



12.5 million hectares
NDC of Brazil

MMA (2017) PLANAVEG, Soares-Filho *et al.* (2014)

TIPPING POINTS & THE PARIS AGREEMENT



Schellnhuber et al. (2016). Nature Climate Change