Geo 873 – 001: Seminar in Human-Environment Geography

12:40 am – 3:30 pm; Geo 120

Global [Climate] Change: Carbon and ESMs

Reading Materials

1) AR6 report video, IPCC, 3/20/2023 (https://www.youtube.com/watch?v=5vJJTE9V7EA)
2) 10 Big Findings from the 2023 IPCC Report on Climate Change (https://www.wri.org/insights/2023-ipcc-ar6-synthesis-report-climate-change-findings)
3) IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. (as a reference, not required to read this 3949-page document)
4) Rubino, M., Etheridge, D. M., Trudinger, C. M., Allison, C. E., Rayner, P. J., Enting, I., ... & Smith, A. M. (2016). Low atmospheric CO2 levels during the Little Ice Age due to cooling-induced terrestrial uptake. Nature Geoscience, 9(9), 691-694. (reference)

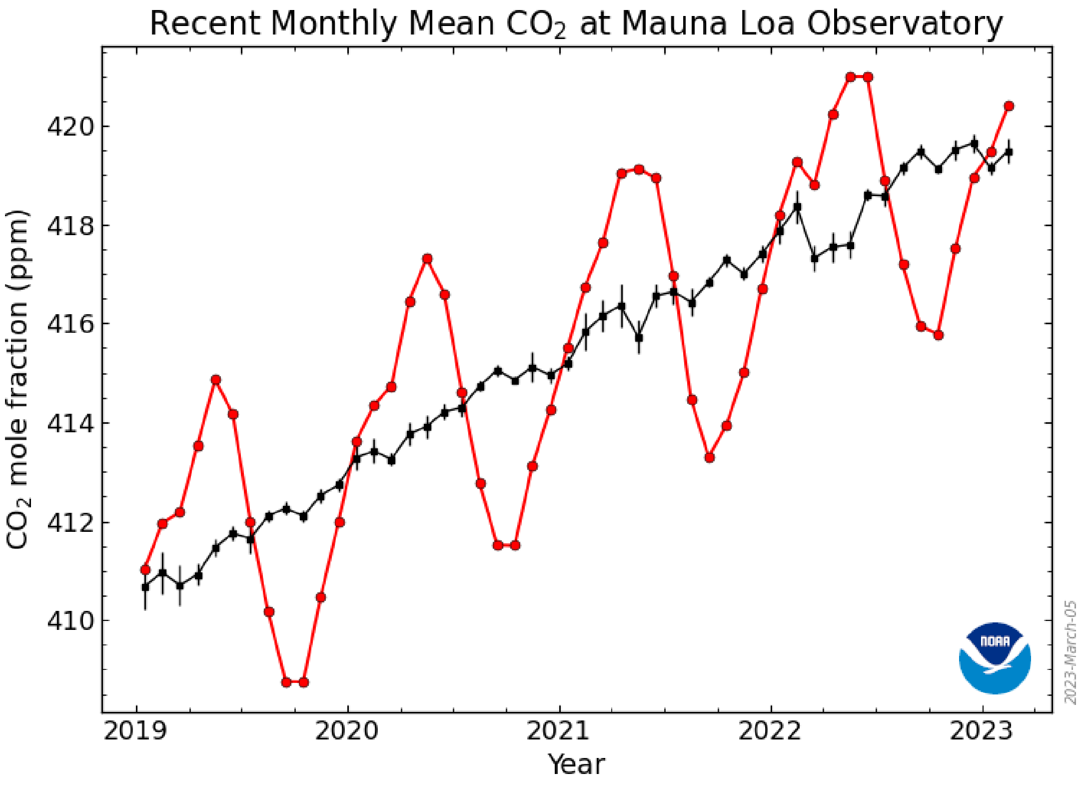
Homework 3 is due at 5:00 pm, 4/3/2023

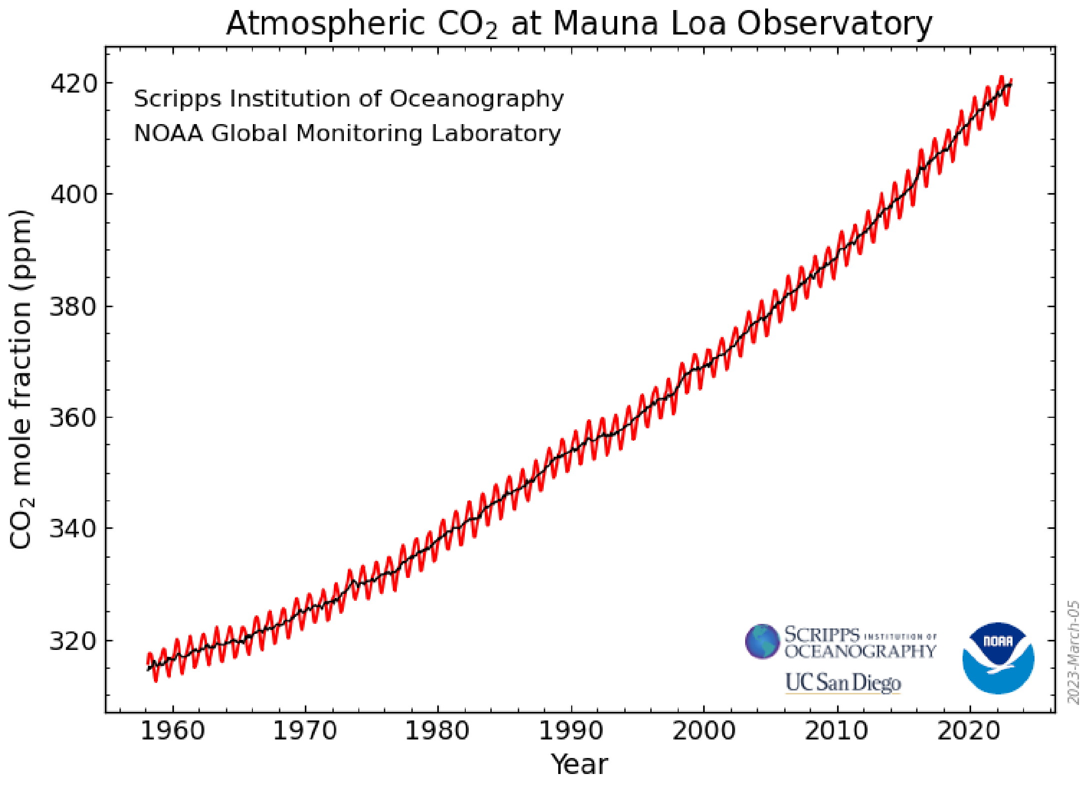
Mar 22-29, 2023

GEO873-001, MSU

Carbon Stories & Climate Change

Monthly Average Mauna Loa CO_2

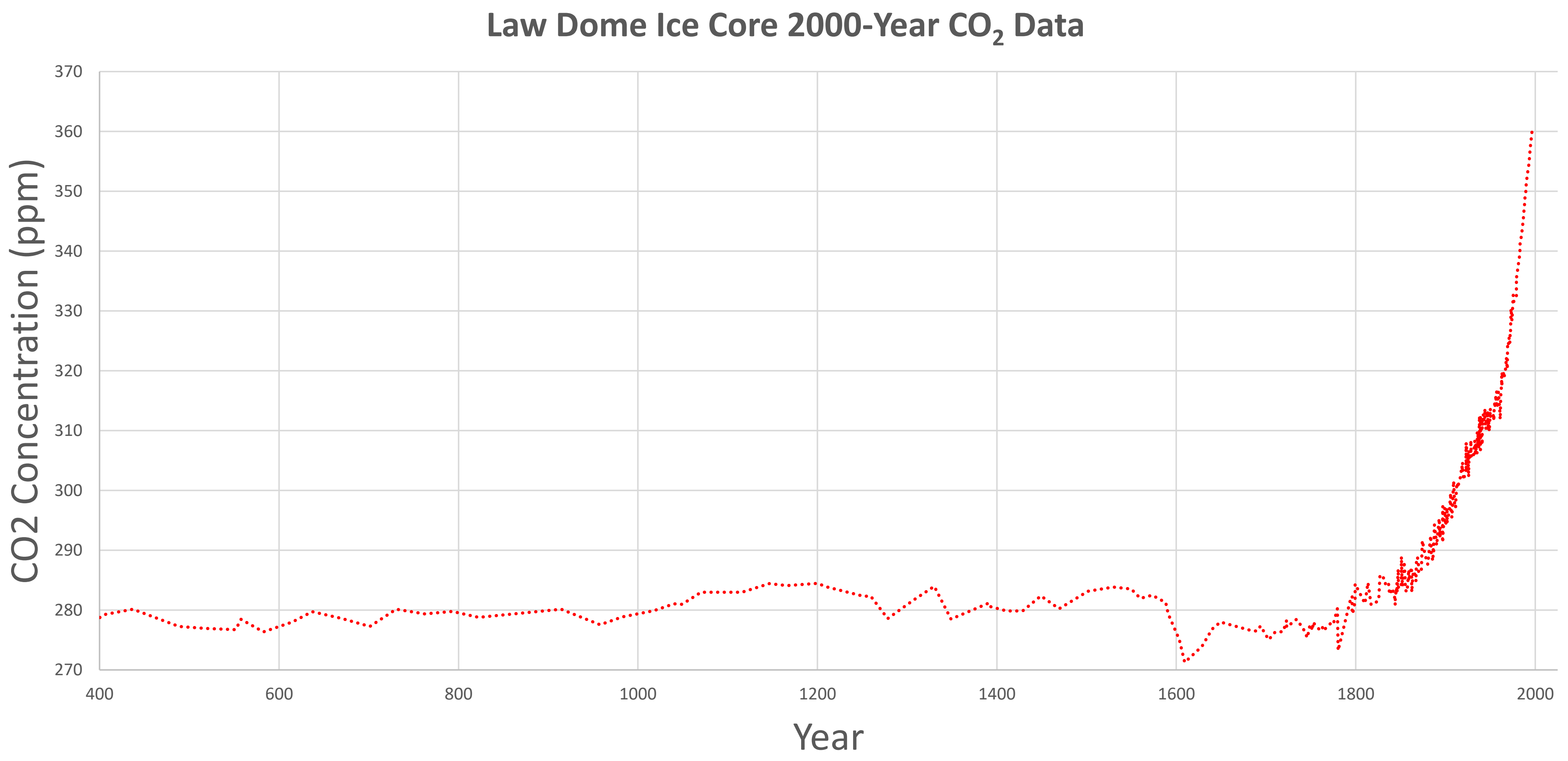





Copyright: Global Carbon Project I Glynn Gorick

Carbon Stories & Climate Change: a few basics

(data from Dr. Dave M. Etheridge, 9/27/2022)



Carbon Stories & Climate Change: a few basics

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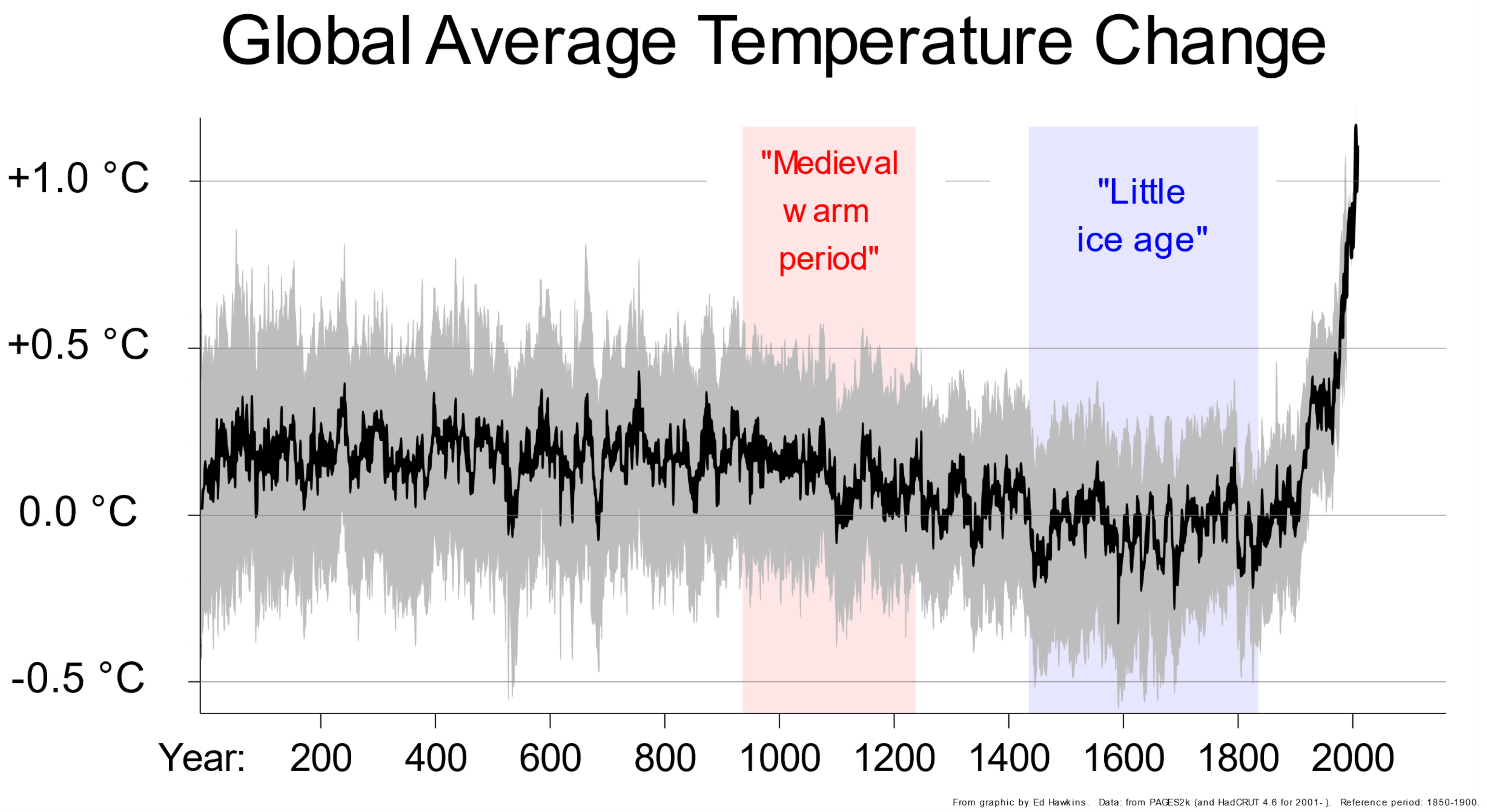
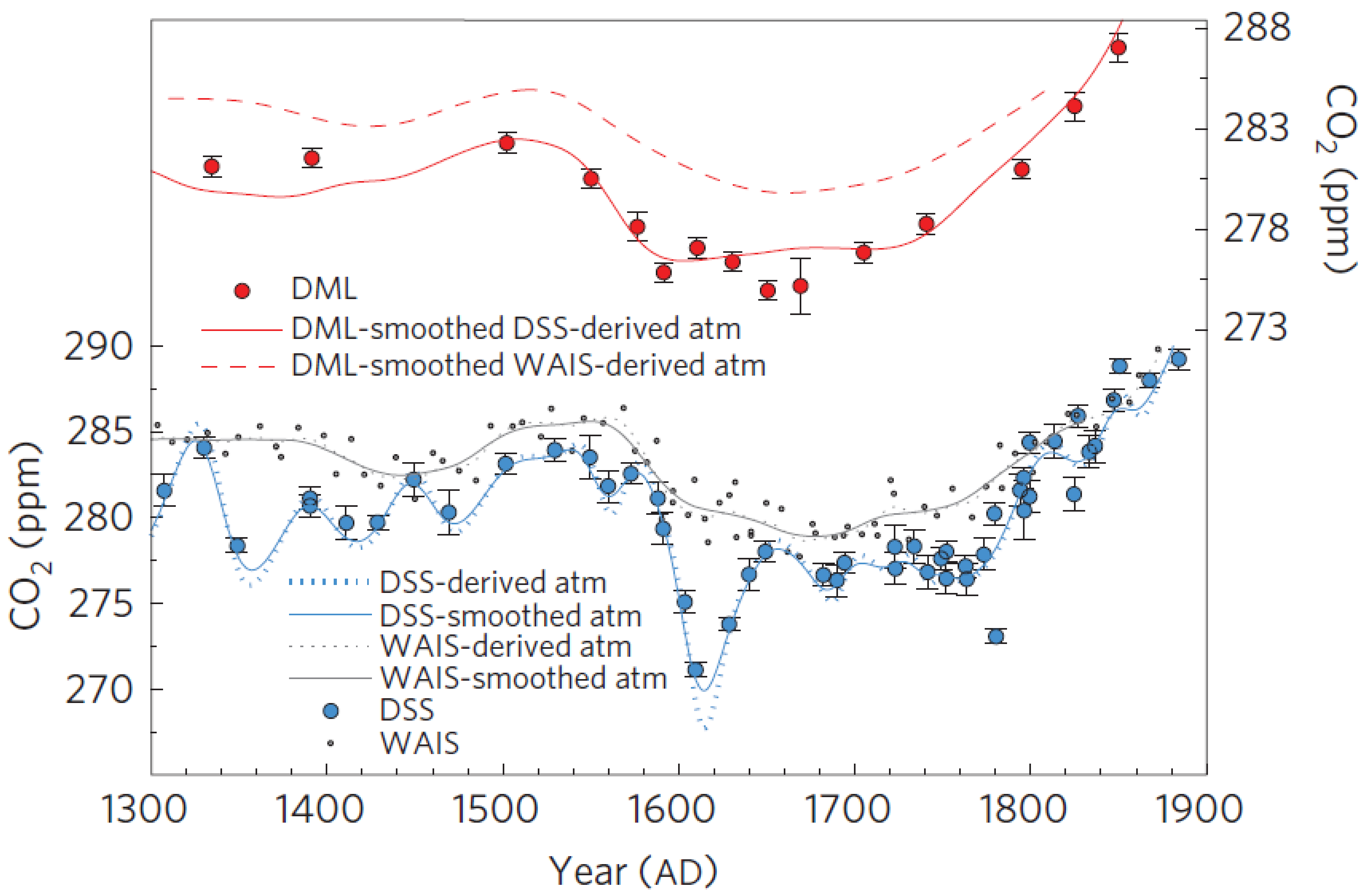


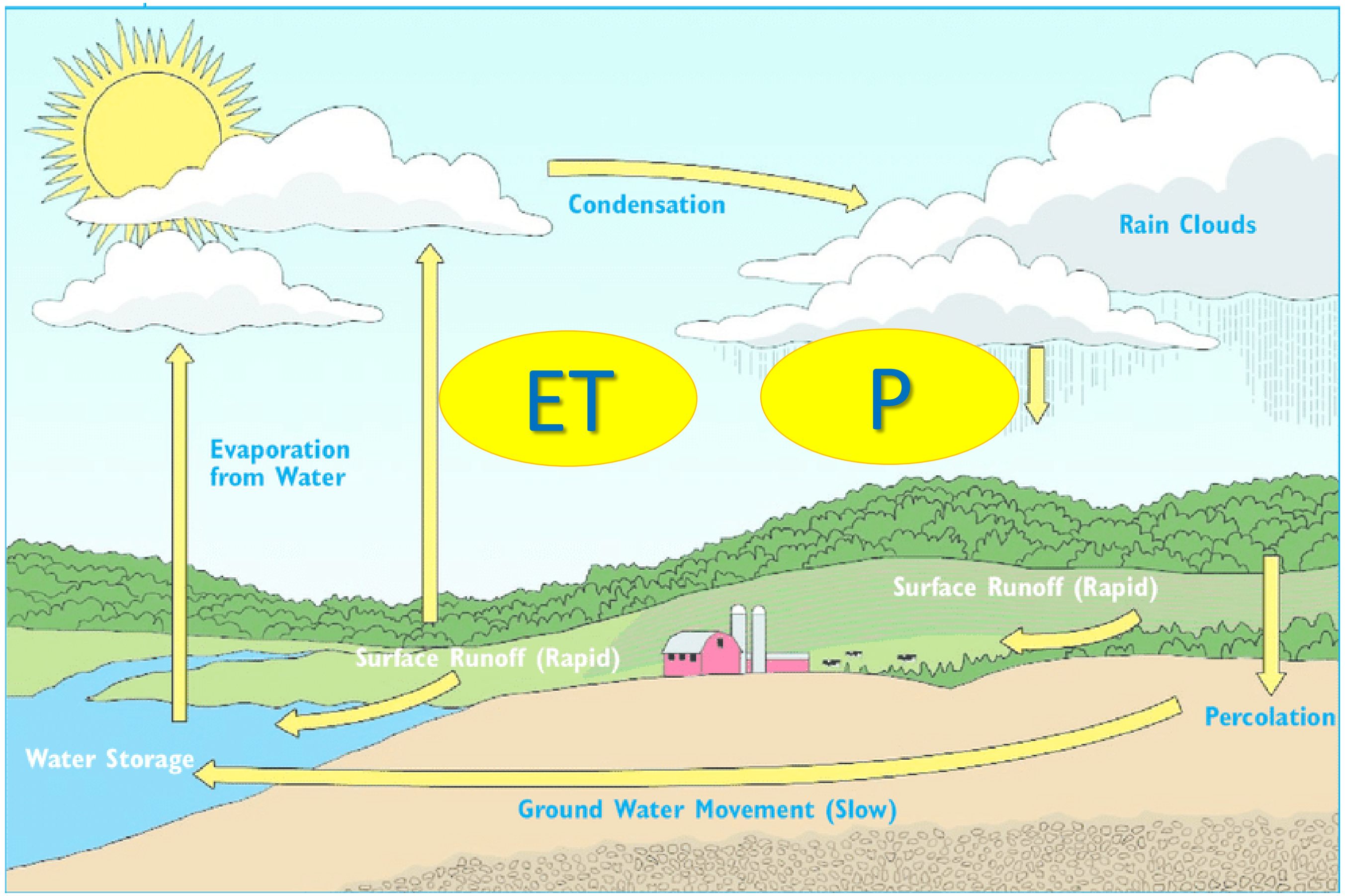
Carbon Stories & Climate Change: a few basics

Robino et al. 2016, nature Geoscience



A thirsty globe!

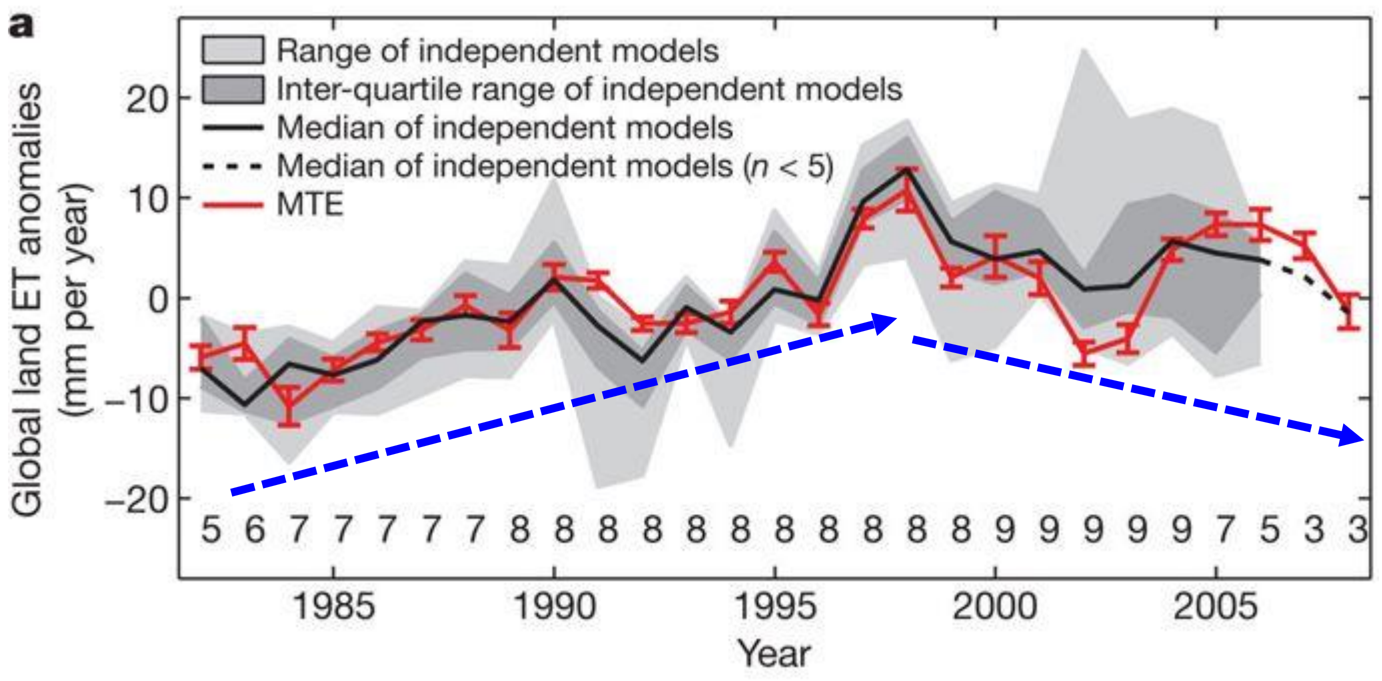
- Evapotranspiration (ET): amount of water evaporated from land surface to the atmosphere
- The total precipitation (P) across the globe remains the same over time
- Change in ET will determines the amount of water for soils, rivers and ground water



A thirsty globe!

Jung et al. 2010. Recent decline in the global land evapotranspiration trend due to limited moisture supply. Nature 467.7318: 951-954.

- Evapotranspiration (ET) has been increasing with warming climate until ~1998, but decreased since then;
- We may have more freshwater;



Unfortunately

This change was driven primarily by moisture limitation in the Southern Hemisphere, particularly Africa and Australia. In these regions, soil moisture decreased from 1998 to 2008. Hence, increasing soil-moisture limitations on ET largely explain the recent decline of the global ET.

UN environment programme

Lake Disappearance!

- Hundreds lakes across the globes disappear each year, especially in dryland regions.
- Over the last 60 years, the lake's size has decreased by 90% as a result of over use of the water, extended drought and the impacts of climate change.
- The surface area of the lake has plummeted from 26,000 km^2 in 1963 to <1,500 km^2 today (2018) -- shrank by 20 times.

List of drying lakes

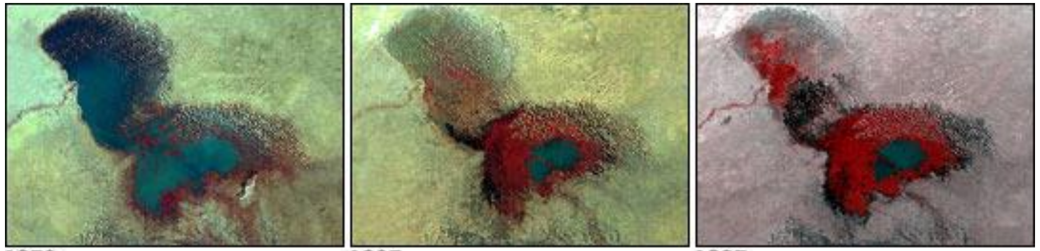
From Wikipedia, the free encyclopedia

A number of lakes throughout the world are drying or completely dry due to irrigation or urban use diverting inflow.[1][2]

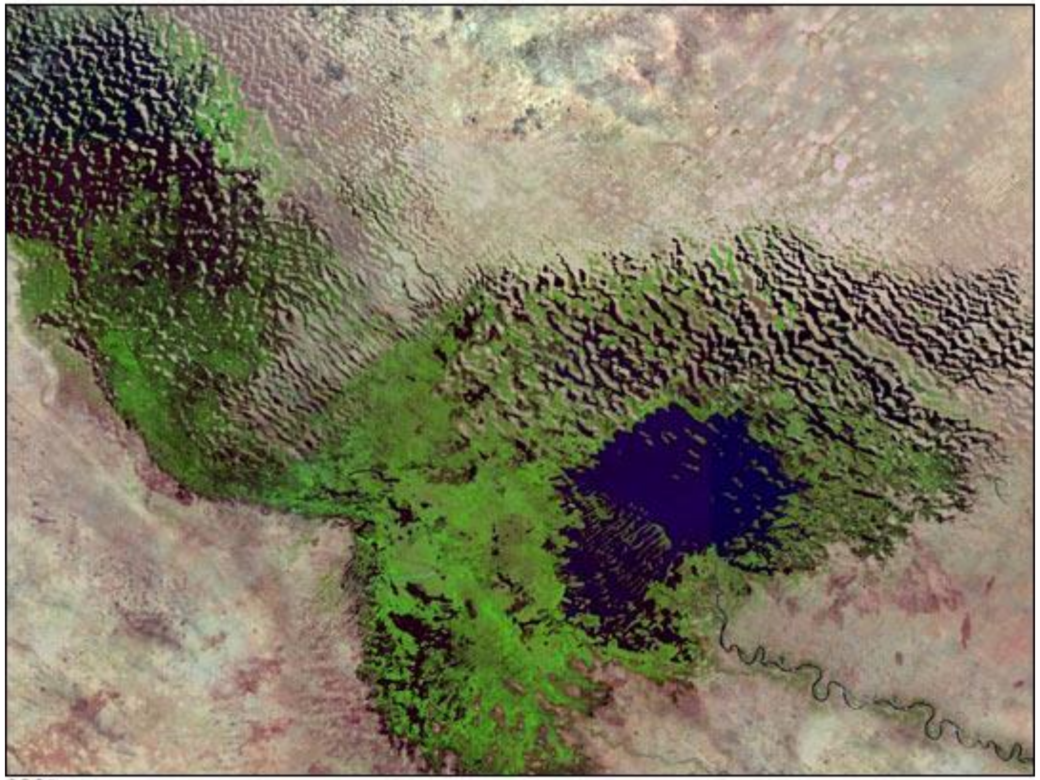
This list is incomplete; you can help by expanding it.

- Dead Sea in Israel, Jordan, and Palestine[3]
- Hamun Lake on the Irano-Afghan border[4]
- Salton Sea in California, U.S.[5]
- Lake Chad in Cameroon, Chad, Niger and Nigeria[6]
- Aral Sea in Kazakhstan and Uzbekistan[7]
- Tulare Lake in California, U.S.[8]
- Lake Urmia in Iran[9]
- Owens Lake in California, U.S.[10]
- Walker Lake in Nevada, U.S.[11]
- Mono Lake in California, U.S.[12]
- Fucine Lake in Italy (fully drained during the 19th century)
- Poyang Lake in Jiangxi, China[13]
- Qinghai Lake in China
- White Bear Lake in Minnesota, U.S.[14]
- Lake Meredith in Texas, U.S.[15]
- Lake Albert in South Australia[16]
- Lake Hindmarsh in Australia[17]
- Lake Poopó in Bolivia[18]
- Lake Copais, in Boeotia, Greece
- Lake George, in New South Wales, Australia[19]
- Nainital, in Uttarakhand, India[20]
- Bakhtegan Lake in Iran
- Lake Amik in Turkey
- Lake Faguibine in Mali[21]
- Lake Chapala in Mexico[22]
- Lake Mead in Nevada and Arizona, U.S.[23]

Lake Chad, once one of the African continent's largest bodies of fresh water, has dramatically decreased in size due to climate change and human demand for water.



1973 1987 1997



2001

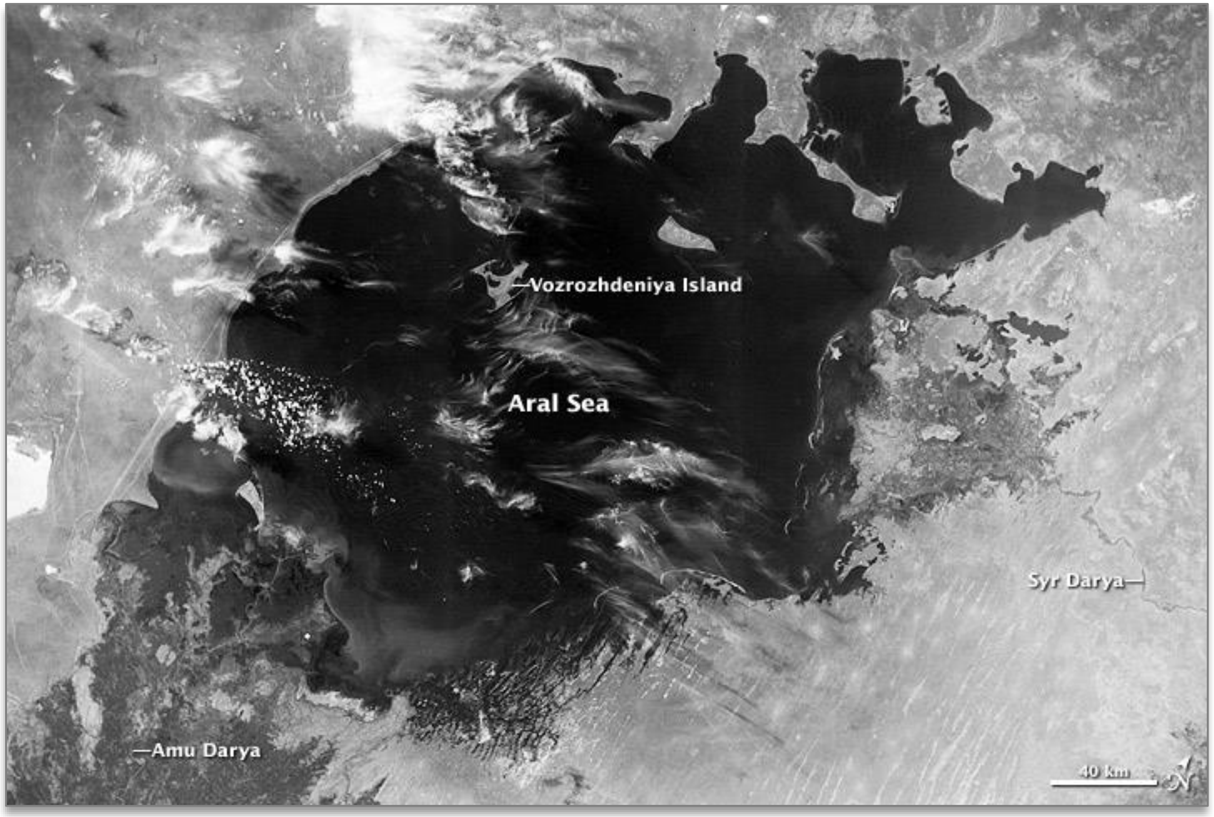
https://earthobservatory.nasa.gov/images/1240/africas-disappearing-lake-chad

About Aral Sea

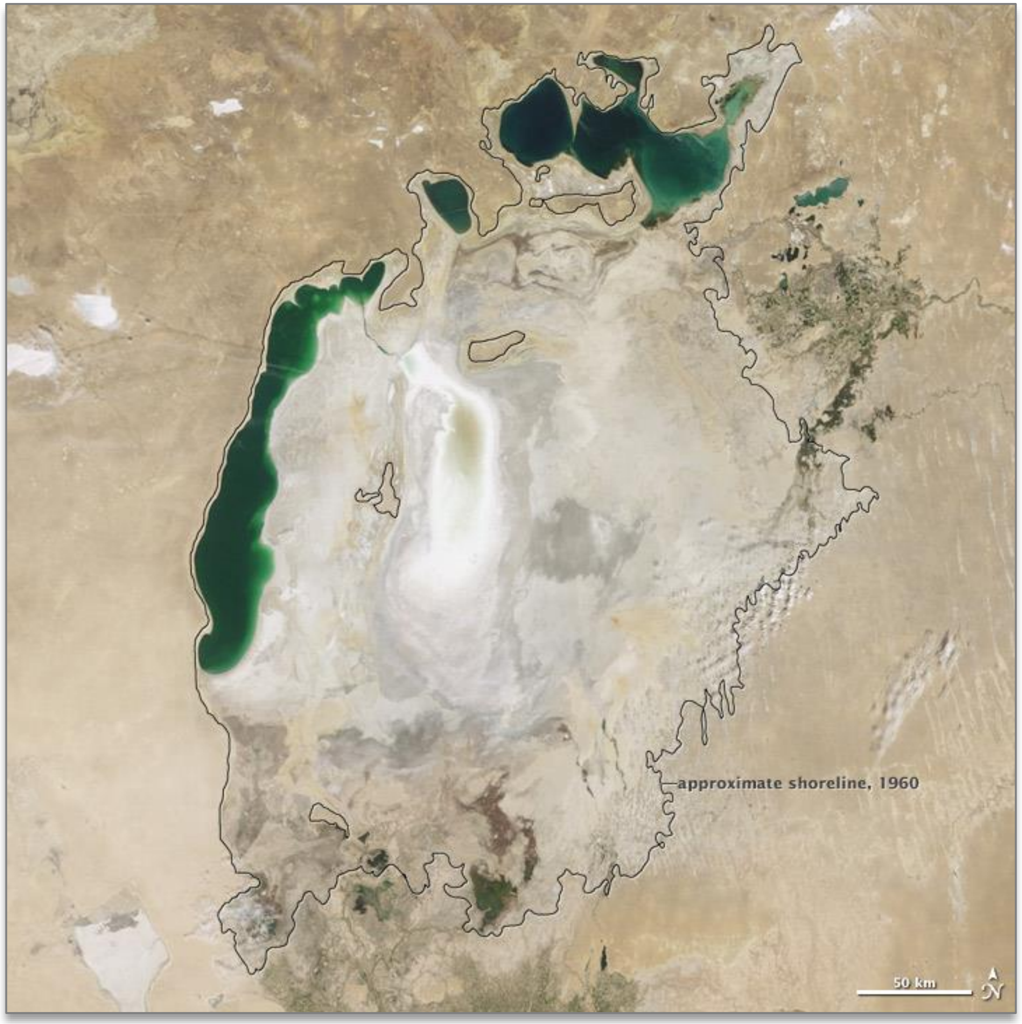
Once the fourth largest lake in the world

About the Aral Sea

1963



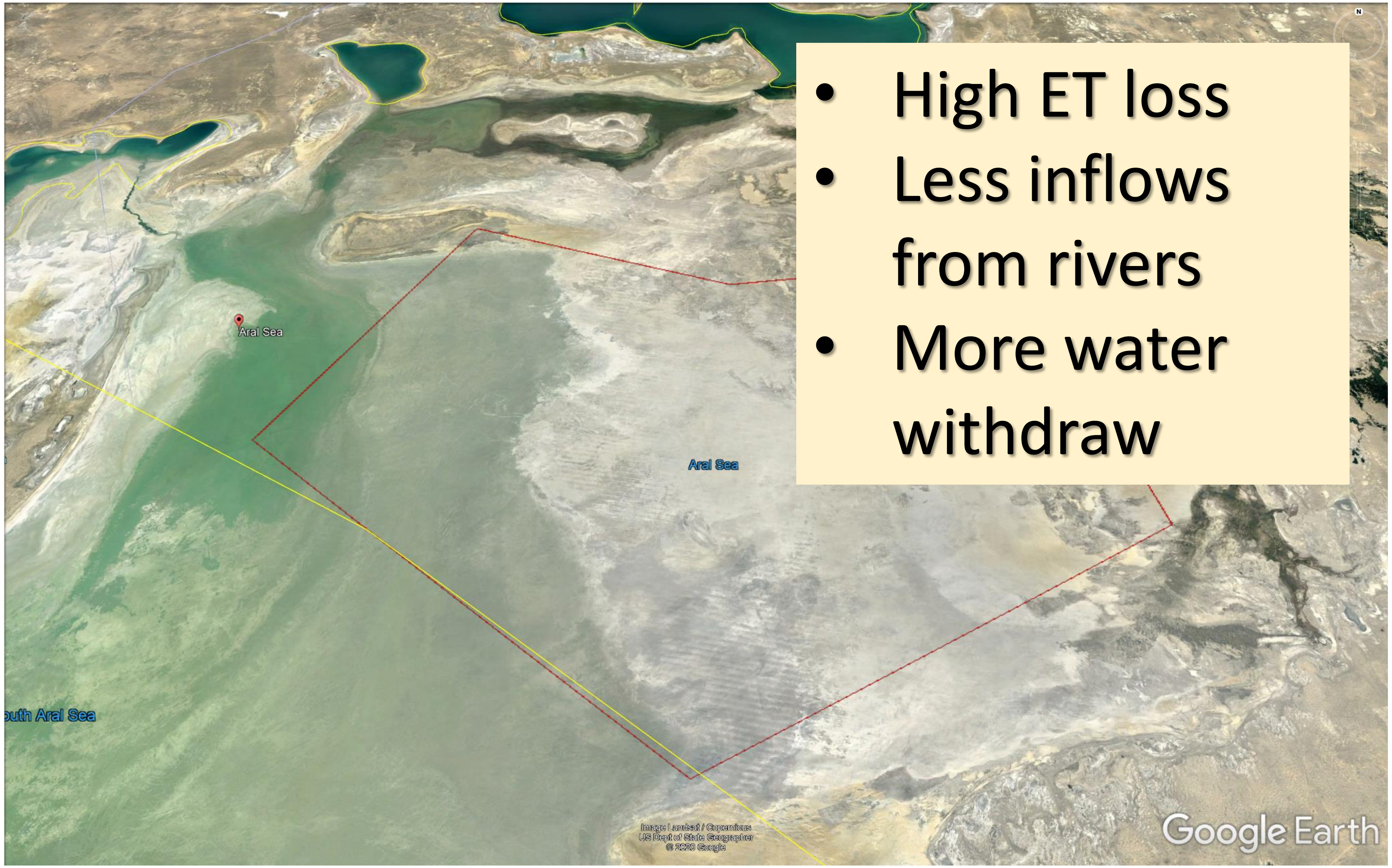
2019



What had happened?

https://youtu.be/UZwLTJroLpE

- Virgin Lands Campaign in mid-1950s for Central Asia during the Soviet time
- Here, most of regional renewable water resources are generated in the mountains where the largest regional rivers originate
- Large-scale irrigation systems have been built to increase the soil fertility to support the agriculture for the Aral Sea
- Reduced inflow and elevated evapotranspiration (ET) caused monumental shrinking of Aral Sea



- High ET loss
- Less inflows from rivers
- More water withdraw

Global Connections: Dairy production in Kazakhstan

PM Mamin holds extended meeting on livestock development

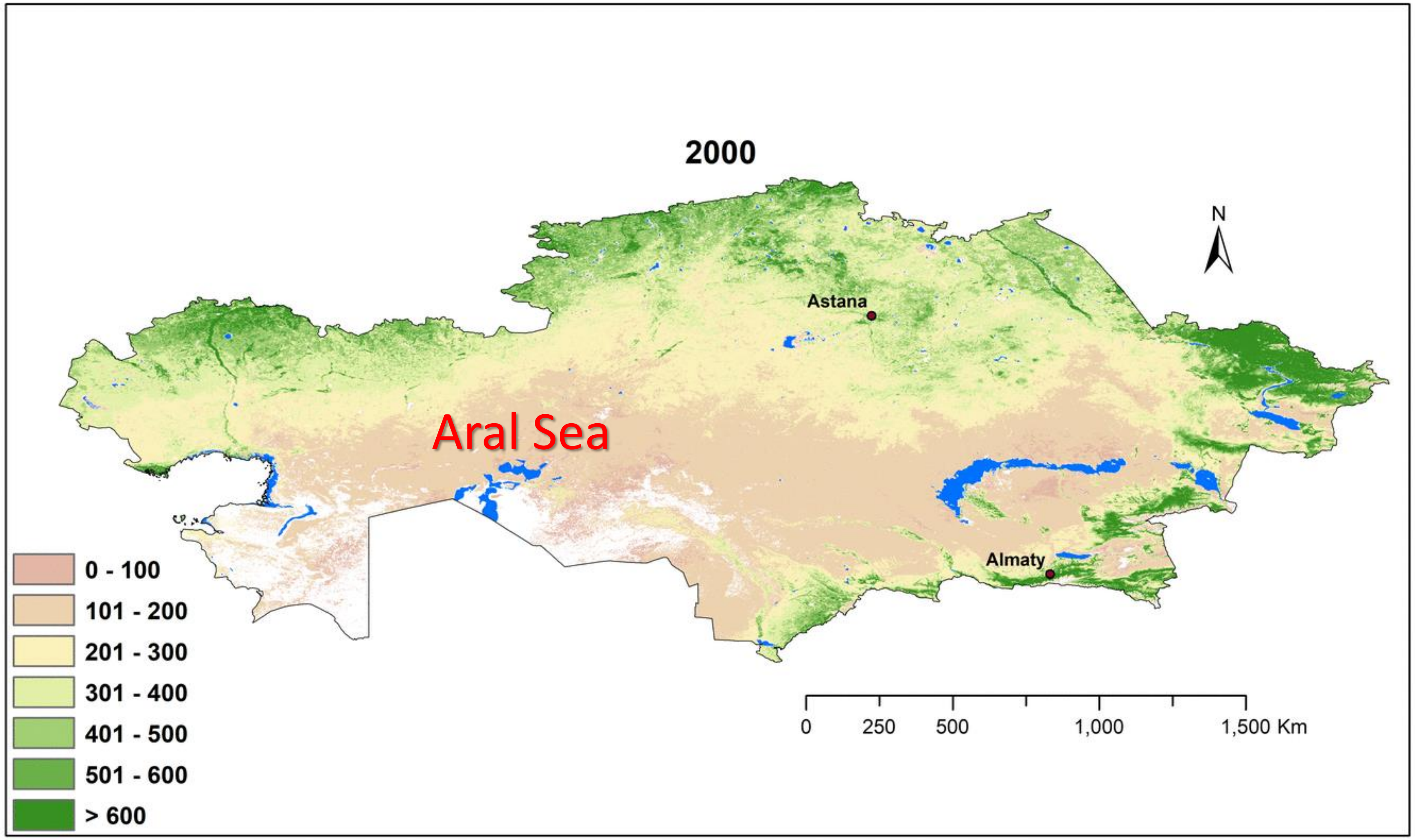
25 December 2019 19:05 Share in:

NUR-SULTAN. KAZINFORM - Prime Minister Askar Mamin chaired a meeting on the development of beef cattle breeding.

- A sectorial program for the development of livestock farming is being implemented in the framework of the State Agro-Industrial Complex Development Program for 2017-2021.
- Kazakhstan is planning to increase the volumes of its meat exports by 2.5 times.
- The main importers of the meat products are Russia, Azerbaijan and Iran.
- Residents of Turkey, the United Arab Emirates, China, Russia and Iran are interested in the meat products from Aral Sea.

Do we have enough grasses to support this large livestock?

Dynamics of net primary ecosystem production (NPP)
in Kazakhstan from 2000 through 2014



Field Trip to Kostanay – a boarding region with Russian

Modern facility and equipment from Italy, Germany, Japan, others

The Tale: Russian Food Table

1) So the reason for more crop/livestock is to satisfy Russians' food table

2) Italy, Japan, China and others all helped

3) Russia needs import diary products regardless of its large lands

4) Economic depression in Russia

Are USA & NATO countries responsible for the shrinking pace of Aral Sea, at least partially?

Or Shall we blame Russians – an easy target

In 2014, Russia interfered Ukraine – from becoming a NATO member

5) USA & NATO Countries imposed sanctions on Russia

Putin was never a fully-fledged climate chang
Addressing a climate conference in 2003, Put
warmer weather so people spend less on fur

Bloomberg Opinion

Technology & Ideas

Even Putin Is Now Worried About Climate Change

Russia has dropped its doubts about joining the Paris accords.

https://www.bloomberg.com/opinion/articles/2019-09-24/putin-is-finally-worried-about-climate-change

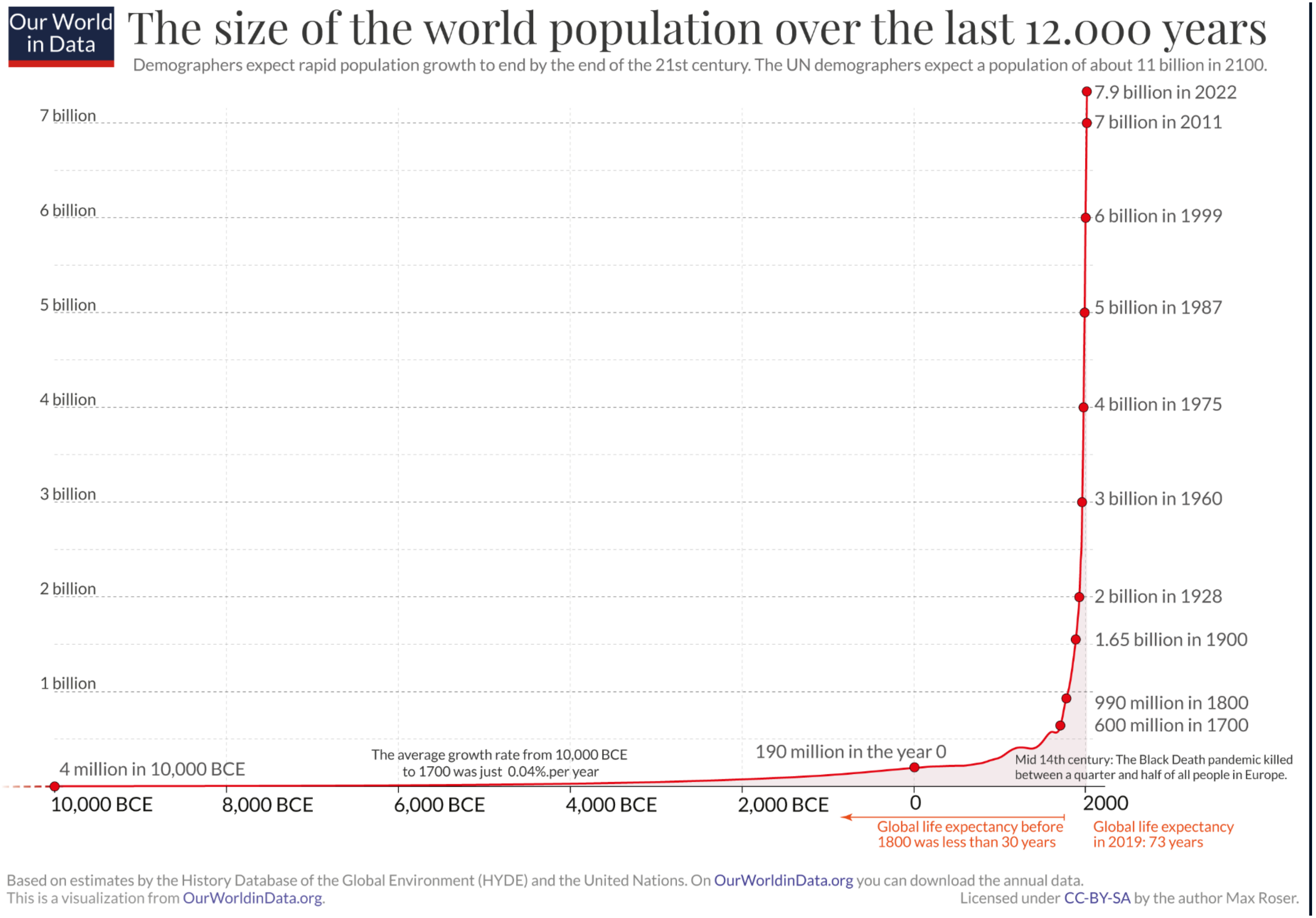
By Leonid Bershidsky
September 24, 2019, 12:00 AM EDT *Corrected September 24, 2019, 3:01 AM EDT*

Russian bears. *Photographer: Alexey Nikolsky/AFP/Getty Images*

Leonid Bershidsky is Bloomberg Opinion's Europe columnist. He was the founding editor of the

After years of procrastination, Russia, the world's fourth-biggest greenhouse gas emitter, has officially joined the Paris climate agreement, which it signed in 2016. It shows that President Vladimir Putin's views of climate change are

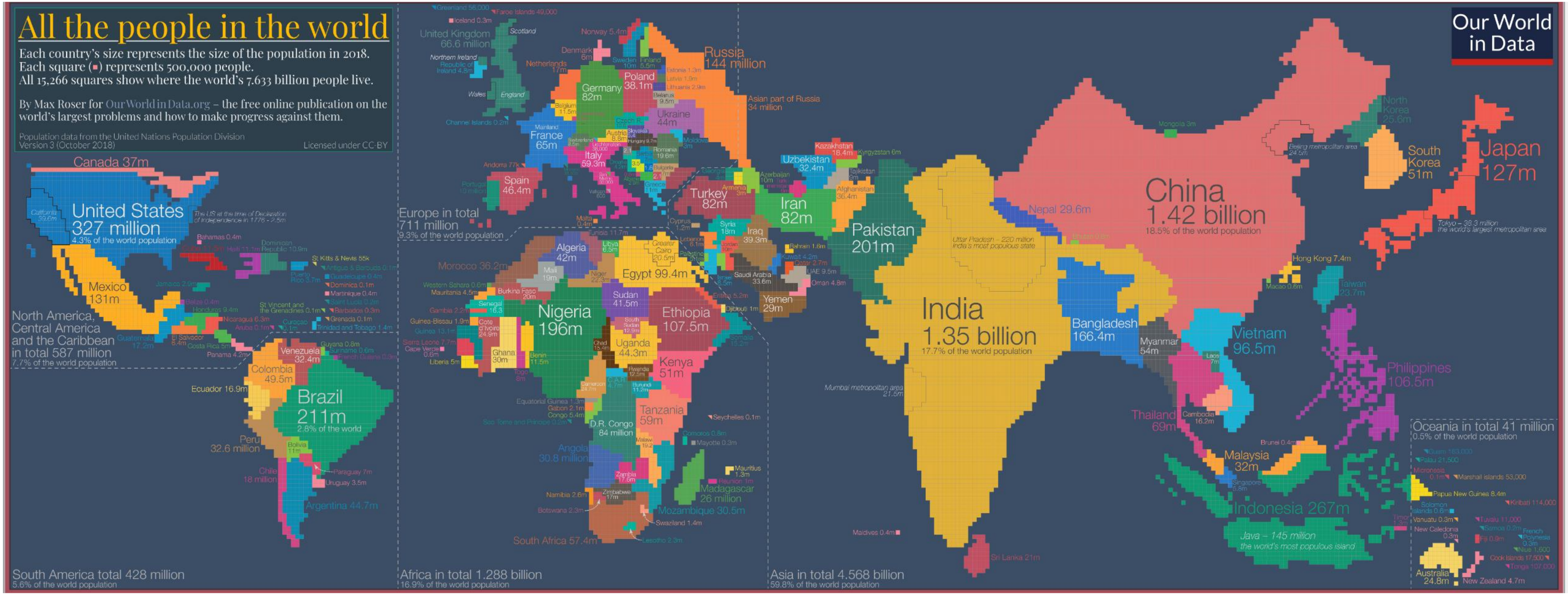
Complex Interconnections: Global Population and growth



https://ourworldindata.org/world-population-growth

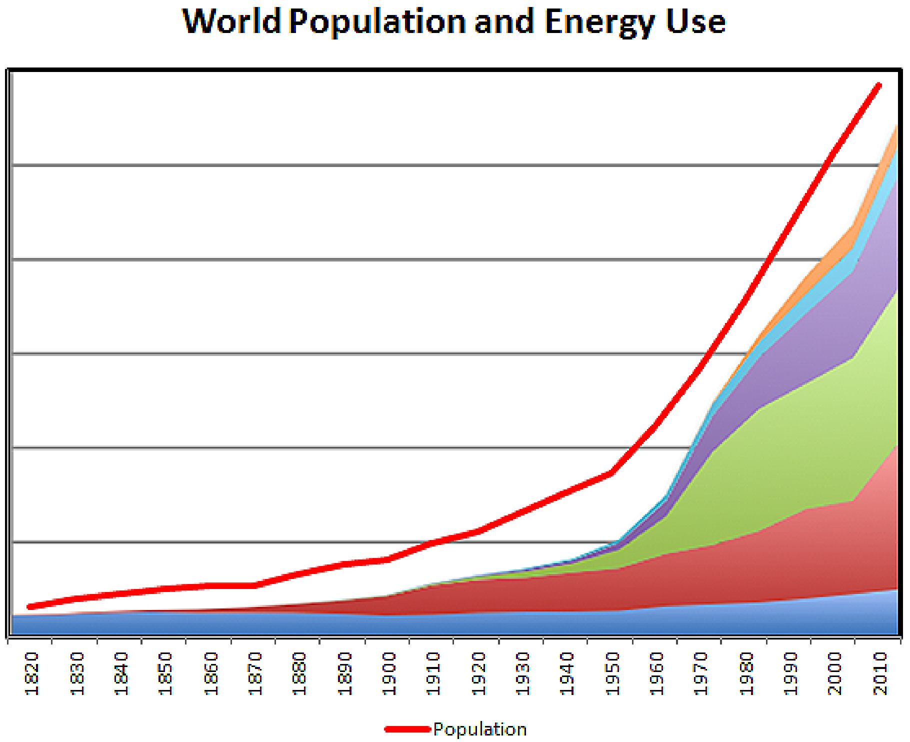
Complex Interconnections: Global Population – uneven distribution

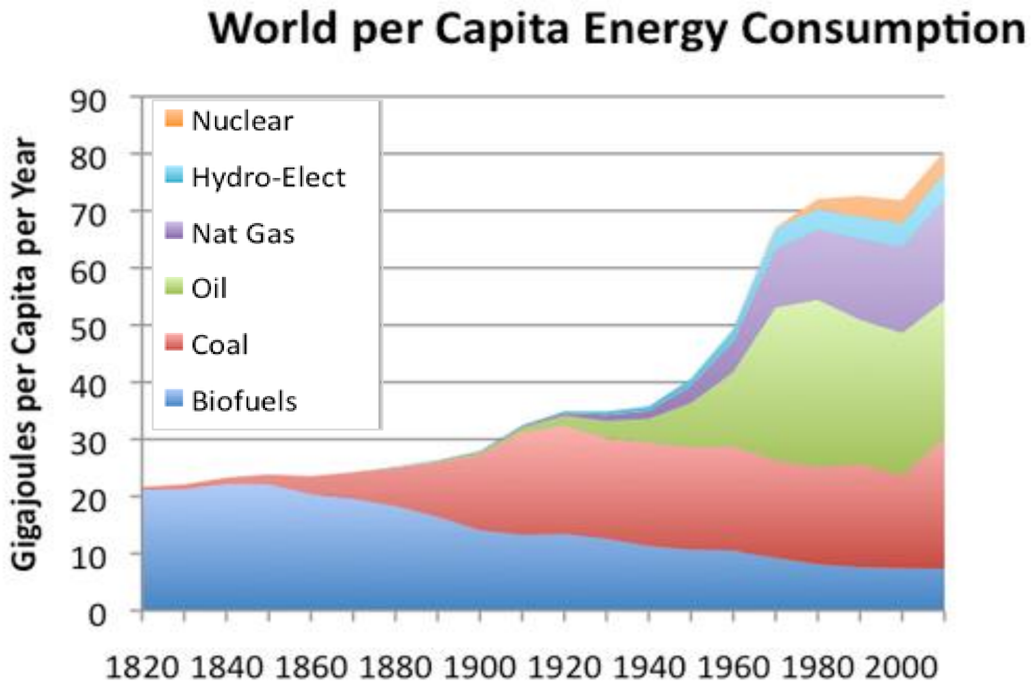
People in developing countries wants the same living standards of Americans!



https://ourworldindata.org/world-population-growth

The world's energy demand is rising!

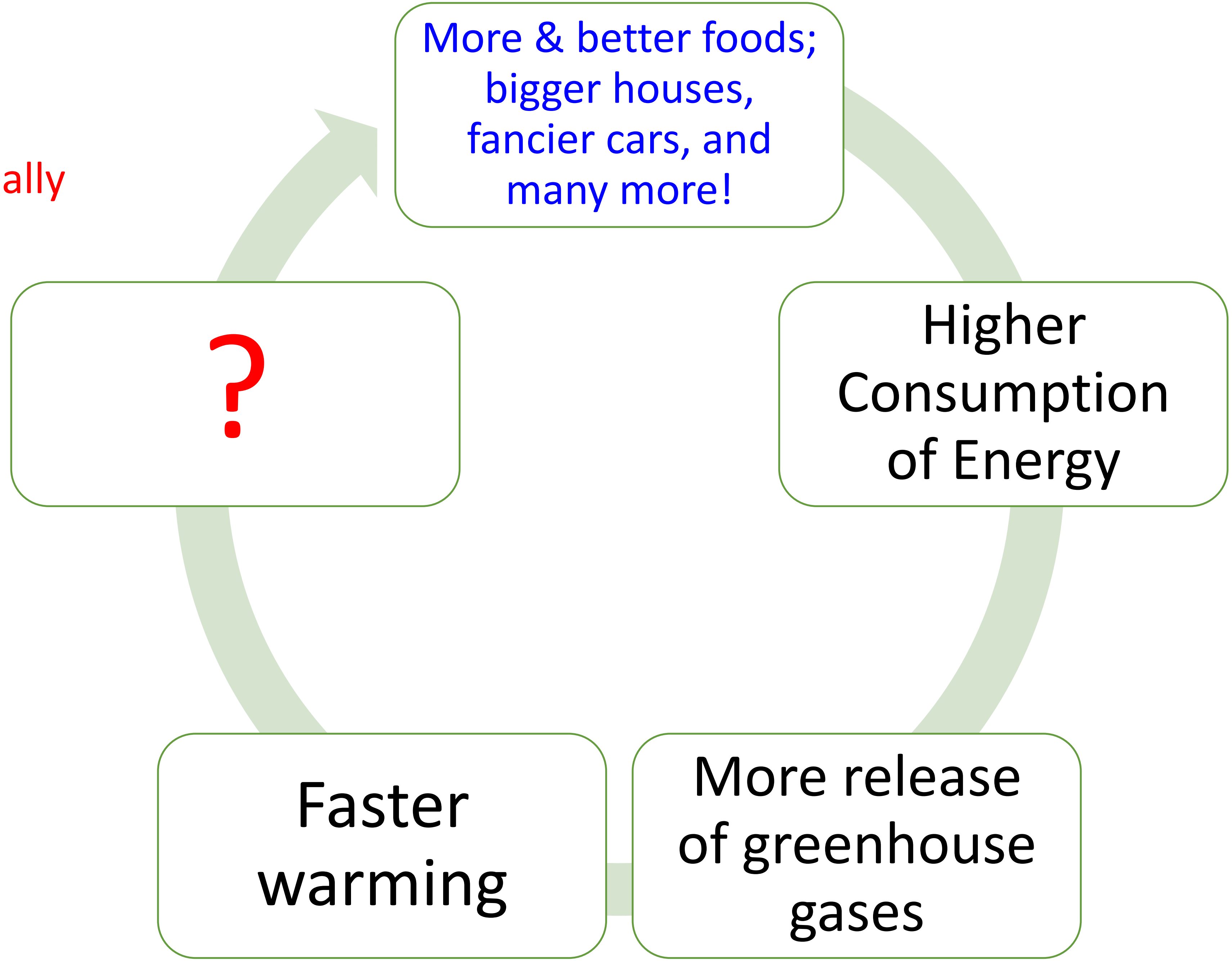




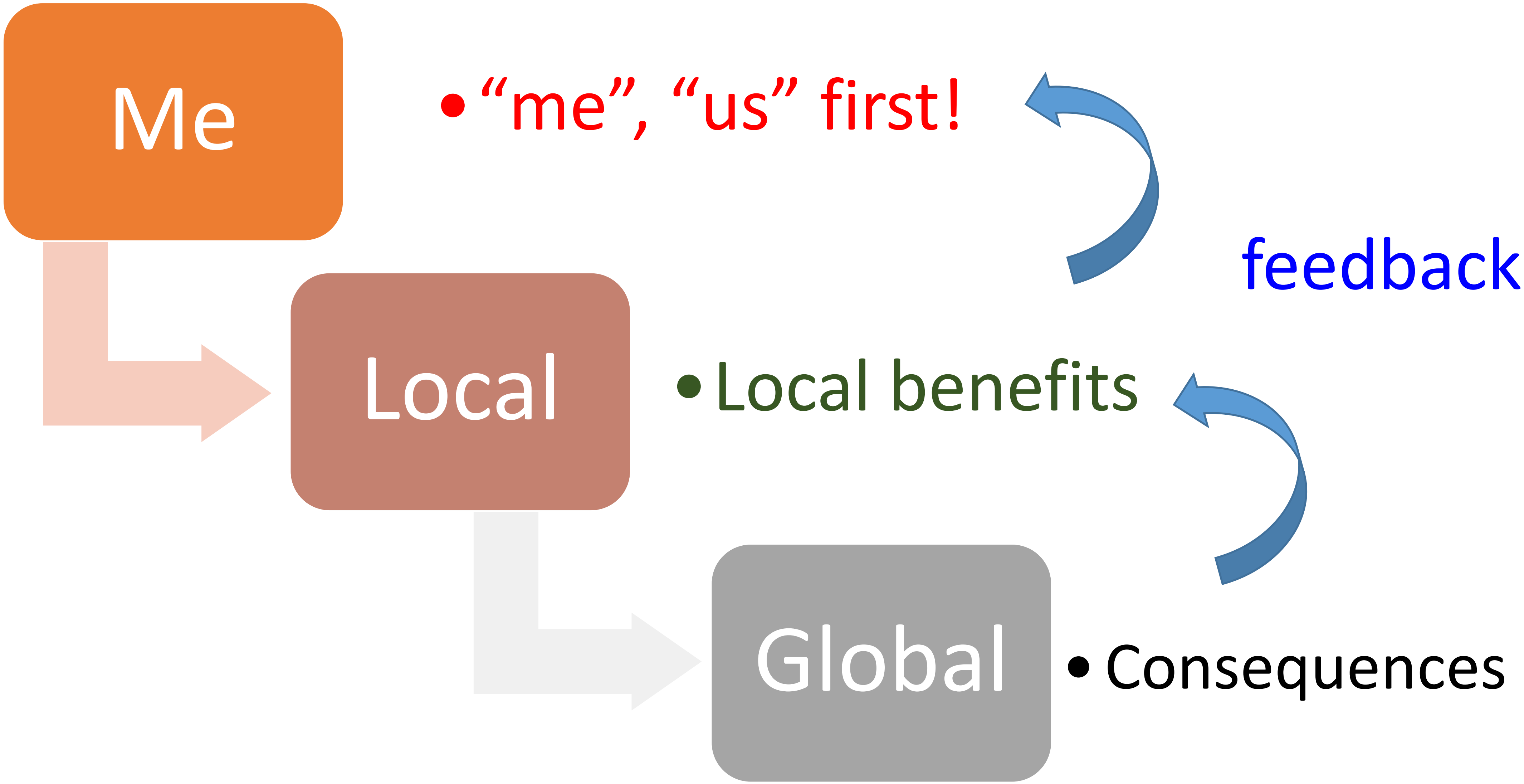
- Nearly 40% of total U.S. energy consumption in 2012 was for residential and commercial buildings;
- Energy consumption has grown exponentially in developing economies (e.g. China, India);
- Governments have pushed a shift from fossil fuels to renewable energy sources, such as solar energy, wind power and biofuels;
- Oil and gas still remain the major primary energy sources to power the world’s industries.

Human Nature:

- A positive feedback
- System collapses, eventually



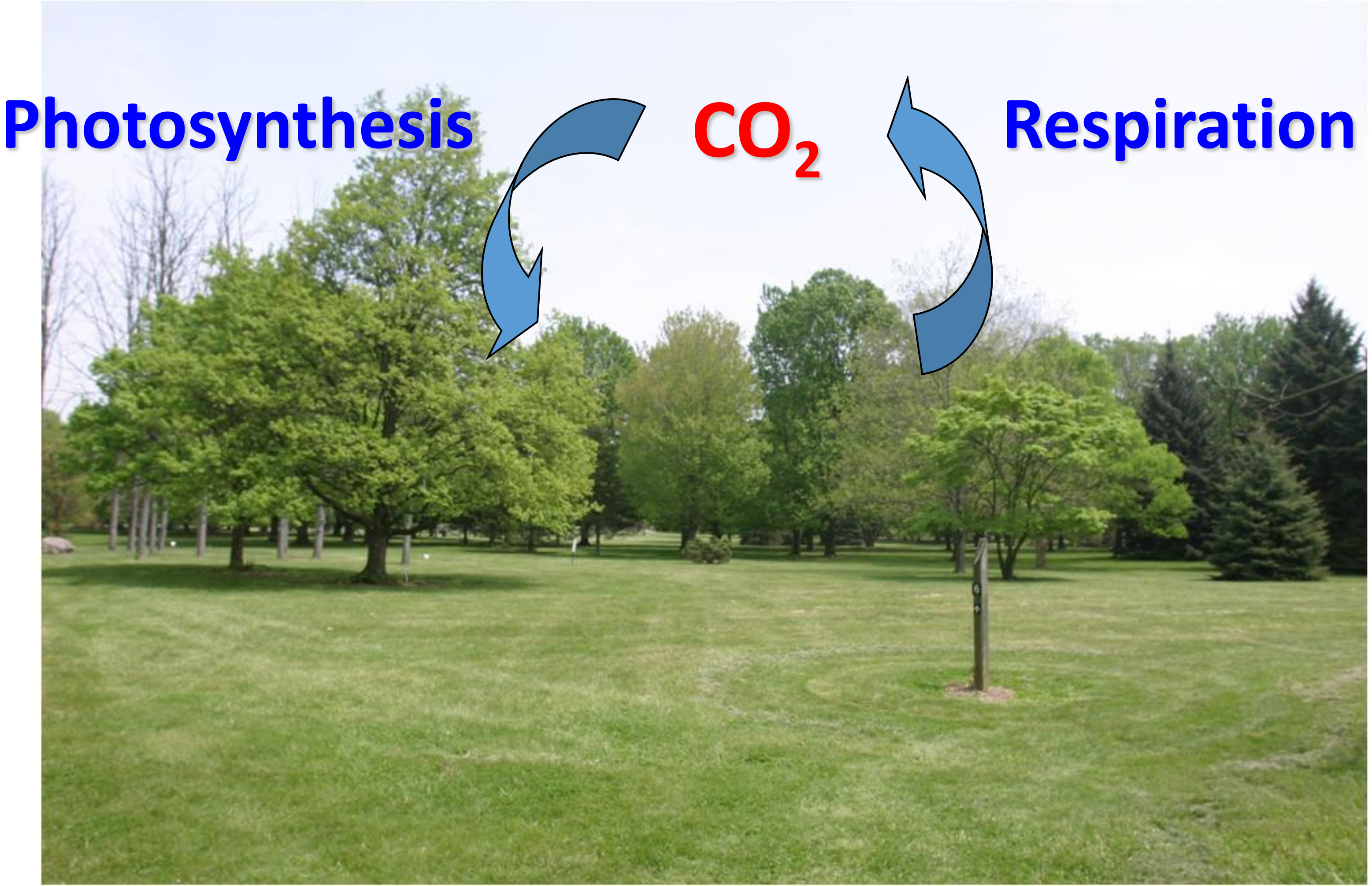
Human Nature



In sum,

1. Globalization is an unavoidable process for now and for the future
2. The changes, including climate, will have consequences (mostly negative so far) on ecosystems, societies, and people
3. Both the causes and consequences are complex and can be remotely connected
4. Solutions are more than just adaptation and mitigation, with education and awareness as the foundational needs for now!

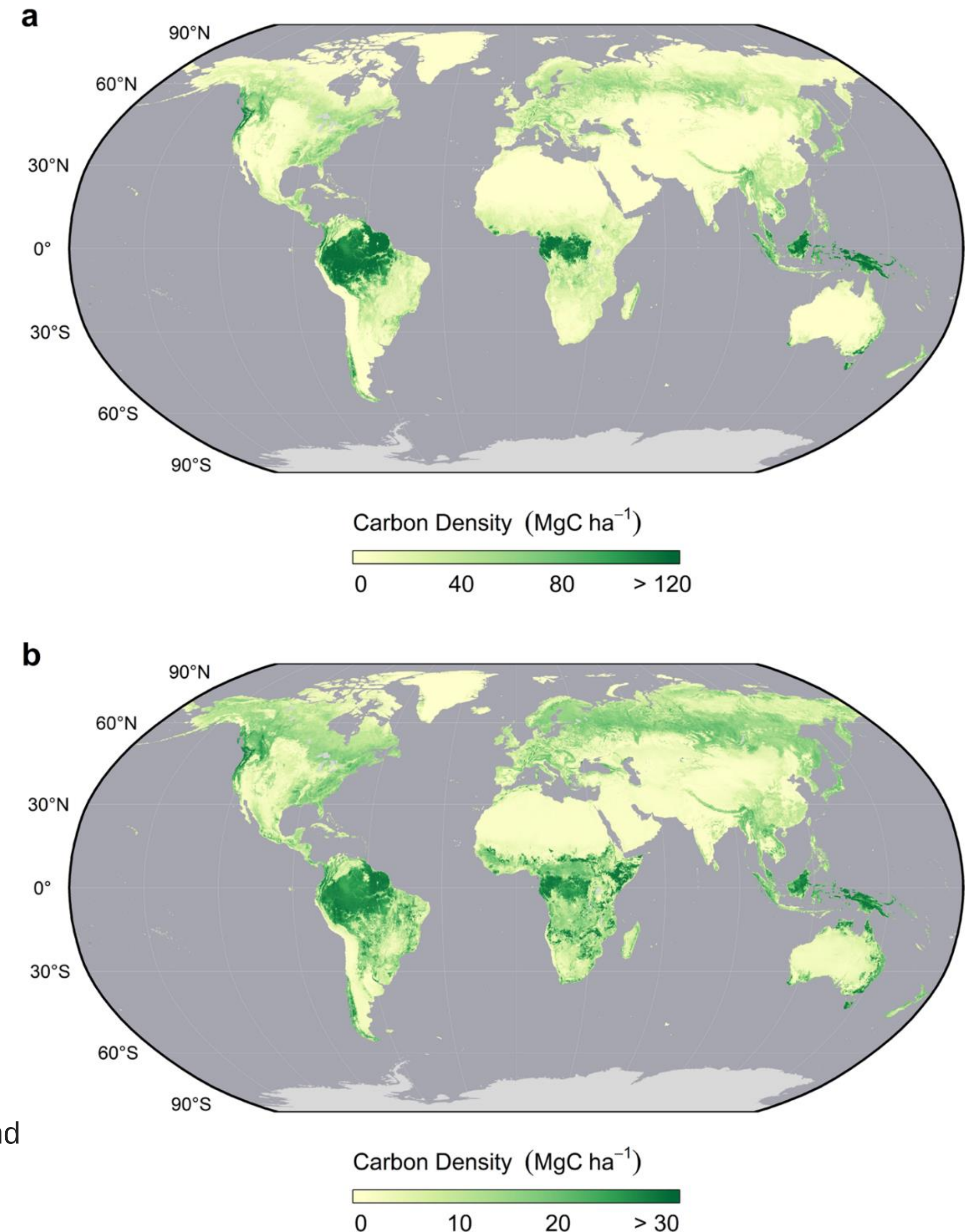
Keeping Carbon in Terrestrial Ecosystems to Battle Global Warming



Carbon Stories & Climate Change: a few basics

(a) Aboveground biomass (AGB) &

(b) (**b**) belowground biomass (BGB)



- Molecular Weight: 12.011 g/mol
- Stable Isotopic C: ^{13}C and ^{14}C
- Molecular Weight of CO_2: 44.01 g/mol
- Carbon Density of biomass: 0.44 – 0.55
- Gasoline is about 87% carbon and 13% hydrogen by weight. So the carbon in a gallon of gasoline (weighing 6.3 pounds) weighs 5.5 pounds (0. 87 x 6.3 pounds = 5.5 pounds).

Spawn, S. A., Sullivan, C. C., Lark, T. J., & Gibbs, H. K. (2020). Harmonized global maps of above and belowground biomass carbon density in the year 2010. *Scientific Data*, *7*(1), 112.

Carbon Stories & Climate Change: a few basics

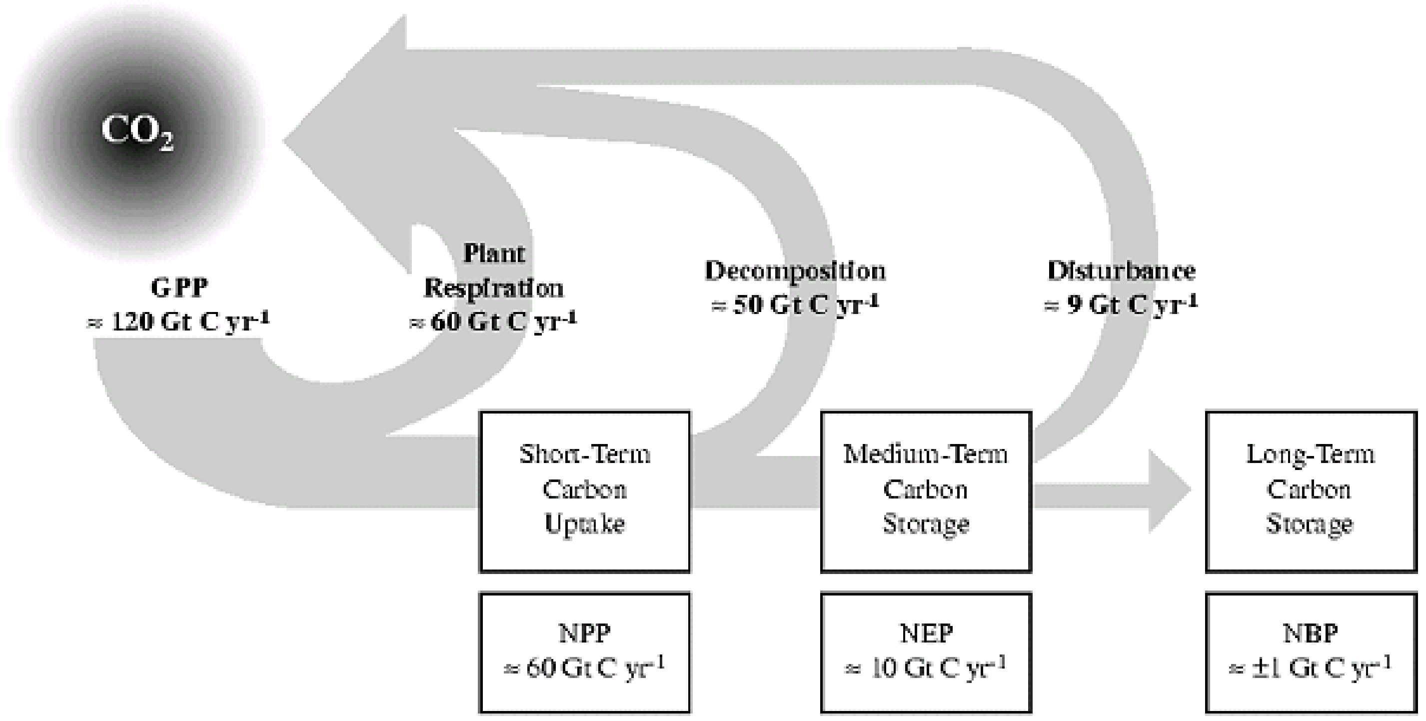


Figure 1-2: *Global terrestrial carbon uptake. Plant (autotrophic) respiration releases CO2 to the atmosphere, reducing GPP to NPP and resulting in short-term carbon uptake. Decomposition (heterotrophic respiration) of litter and soils in excess of that resulting from disturbance further releases CO2 to the atmosphere, reducing NPP to NEP and resulting in medium-term carbon uptake. Disturbance from both natural and anthropogenic sources (e.g., harvest) leads to further release of CO2 to the atmosphere by additional heterotrophic respiration and combustion-which, in turn, leads to long-term carbon storage (adapted from Steffen et al., 1998).*

https://archive.ipcc.ch/ipccreports/sres/land_use/index.php?idp=24

Carbon Stories & Climate Change: a few basics

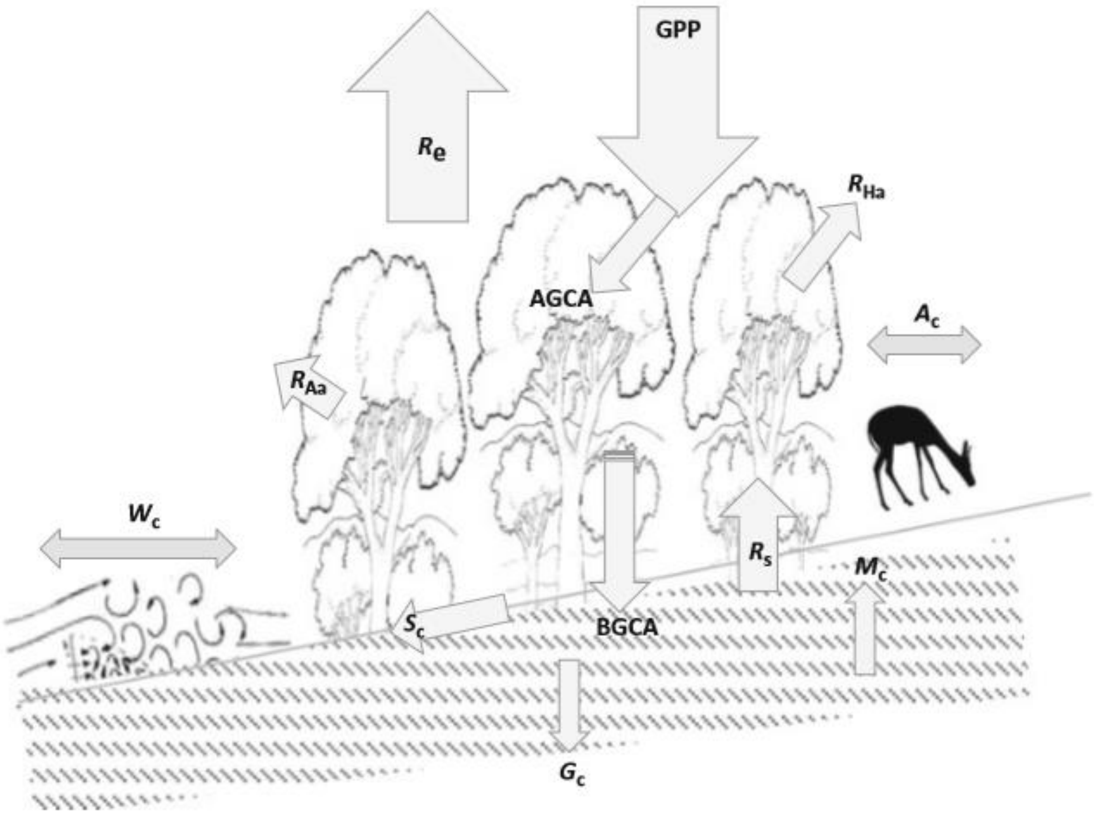


Figure 6.1 Illustration of the major carbon fluxes in a forest ecosystem, including gross primary production (GPP), ecosystem respiration (R_e), aboveground carbon allocation (AGCA), below-ground carbon allocation (BGCA), soil respiration (R_s), aboveground heterotrophic respiration (R_{Ha}), aboveground autotrophic respiration (R_{Aa}), surface runoff (S_c), lateral fluxes of carbon through the wind (W_c) and animals (A_c), vertical water leaching (G_c), and upward movement through diffusion after weathering of bedrock (M_c) in the soil

Carbon Stories & Climate Change: a few basics

Table 6.1. Carbon storage as aboveground biomass (AGB), belowground biomass (BGB), and coarse woody debris (CWD), and the total of these three components, in selected representative forests from the three dominant forest biomes.

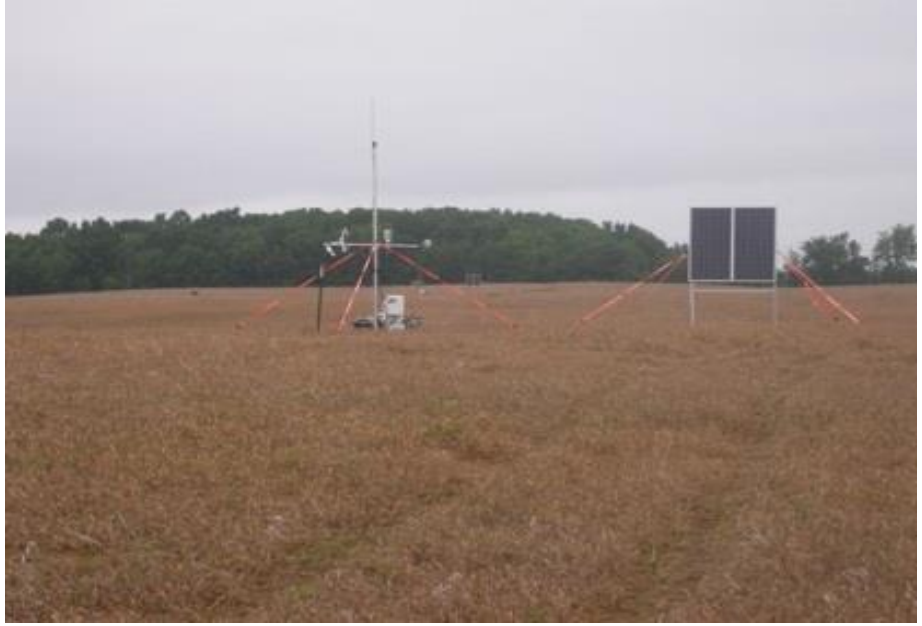
			Carbon storage (Mg C ha^{-1})				
Biome	Region	Dominant species	AGB	BGB	CWD	Total	Source
Tropical	Tapajos National Forest	*Sclerobium chrysophyllum*	305.00	NA	NA	339.2	Nepstad et al. (2002)
	Sabah, Borneo	*Shorea* spp.	128.00	NA	70.60	210.75	Saner et al. (2012)
Temperate	WRCCRF, WA, USA	*Pseudotsuga menziesii*	313.23	174.22	NA	487.45	Harmon et al. (2004)
	MOFEP, MO, USA	*Quercus* spp.	80.20	73.70	22.90	182.7	Li et al. (2007b)
	Walker Branch, TN, USA	*Quercus* spp. *Acer* spp.	97.30	91.90	NA	189.20	Curtis et al. (2002)
	MMSF, IN, USA	*Acer saccharum* *Quercus* spp.	101.90	124.30	NA	226.20	Curtis et al. (2002)
	Harvard Forest, MA, USA	*Quercus* spp.	105.00	111.60	NA	216.60	Curtis et al. (2002)
	UMBS, MI, USA	*Populus* spp.	62.60	NA	NA	78.60	Curtis et al. (2002)
	Willow Creek, WI, USA	*Populus* spp. and *Acer* spp.	78.60	222.70	NA	301.03	Curtis et al. (2002)
	Victoria, Australia	*Eucalyptus regnans*	1819.0	1025.0	NA	2844.0	Keith et al. (2009)
	Chiloé Island, Chile	*Nothofagus nitida*	290.50	NA	158.00	448.50	Carmona et al. (2002)
Boreal	Saskatchewan, Canada	*Populus* spp.	93.34	35.99	291.10	158.44	Gower et al. (1997)
		Picea mariana	49.24	390.36	61.60	445.76	Gower et al. (1997)
		Pinus banksiana	34.55	14.20	202.30	68.98	Gower et al. (1997)
	Manitoba, Canada	*Populus* spp.	56.95	97.170	222.70	176.39	Gower et al. (1997)
		Picea mariana	57.21	418.36	38.10	479.38	Gower et al. (1997)
		Pinus banksiana	28.99	25.78	136.00	68.37	Gower et al. (1997)

Research Questions (current)

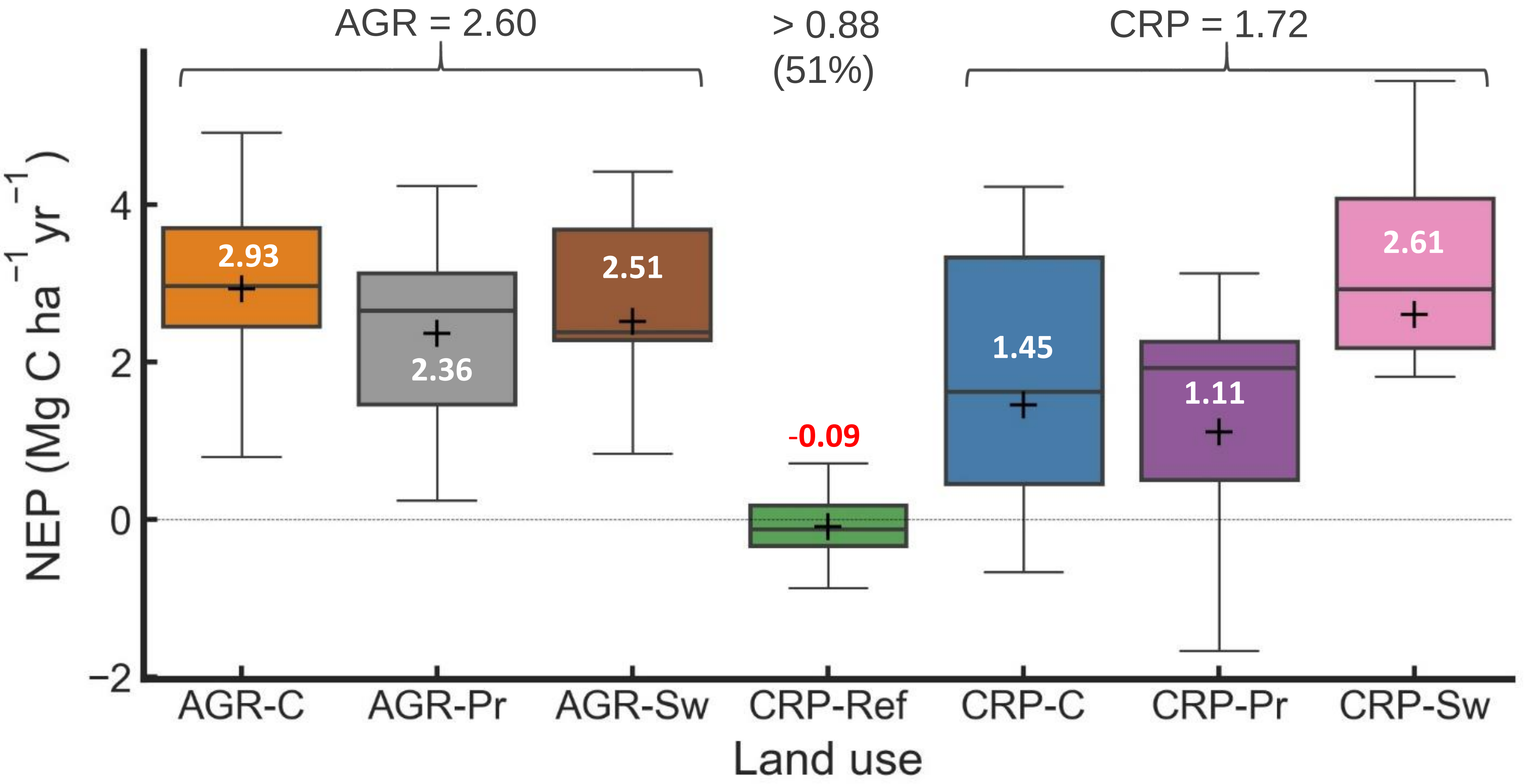
1. How does land use conversion to bioenergy crops influence ecosystem C fluxes?

2. How does this vary by crop (annual corn *vs.* perennials switchgrass or restored prairie)?

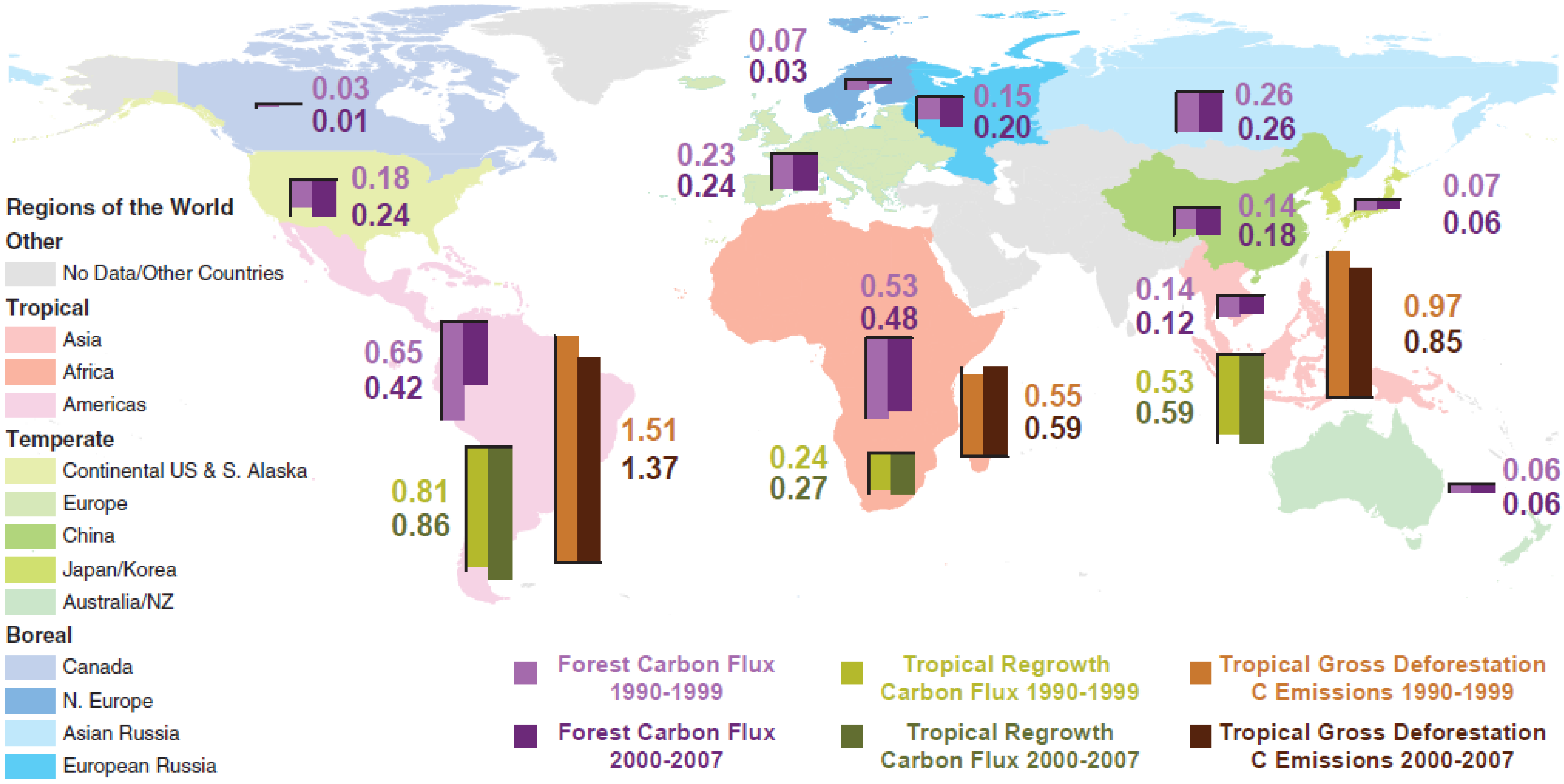
3. How long does it take for such bioenergy crops to realize ecosystem C benefits?



Net Ecosystem Production (NEP; 2009–2021)



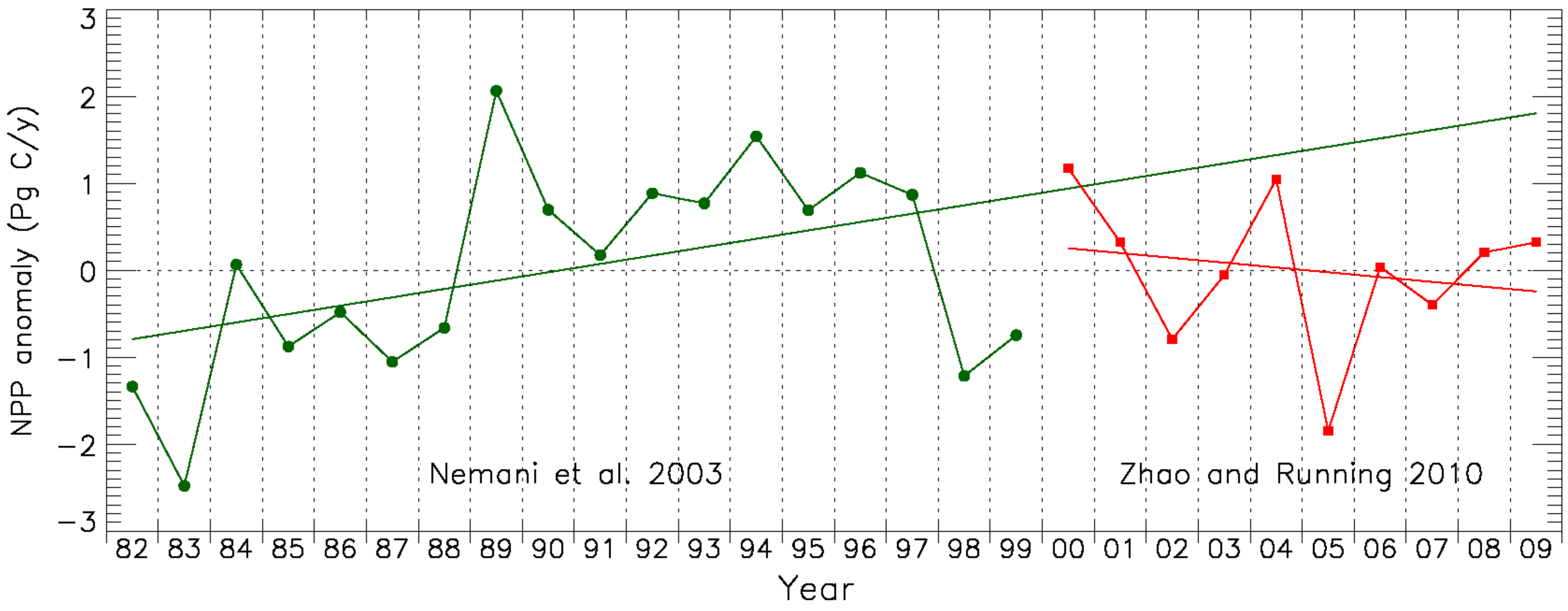
Carbon Sinks and Sources (Pg C yr^{-1}) in the World's Forests



Pan *et al*. (2011) *Science*

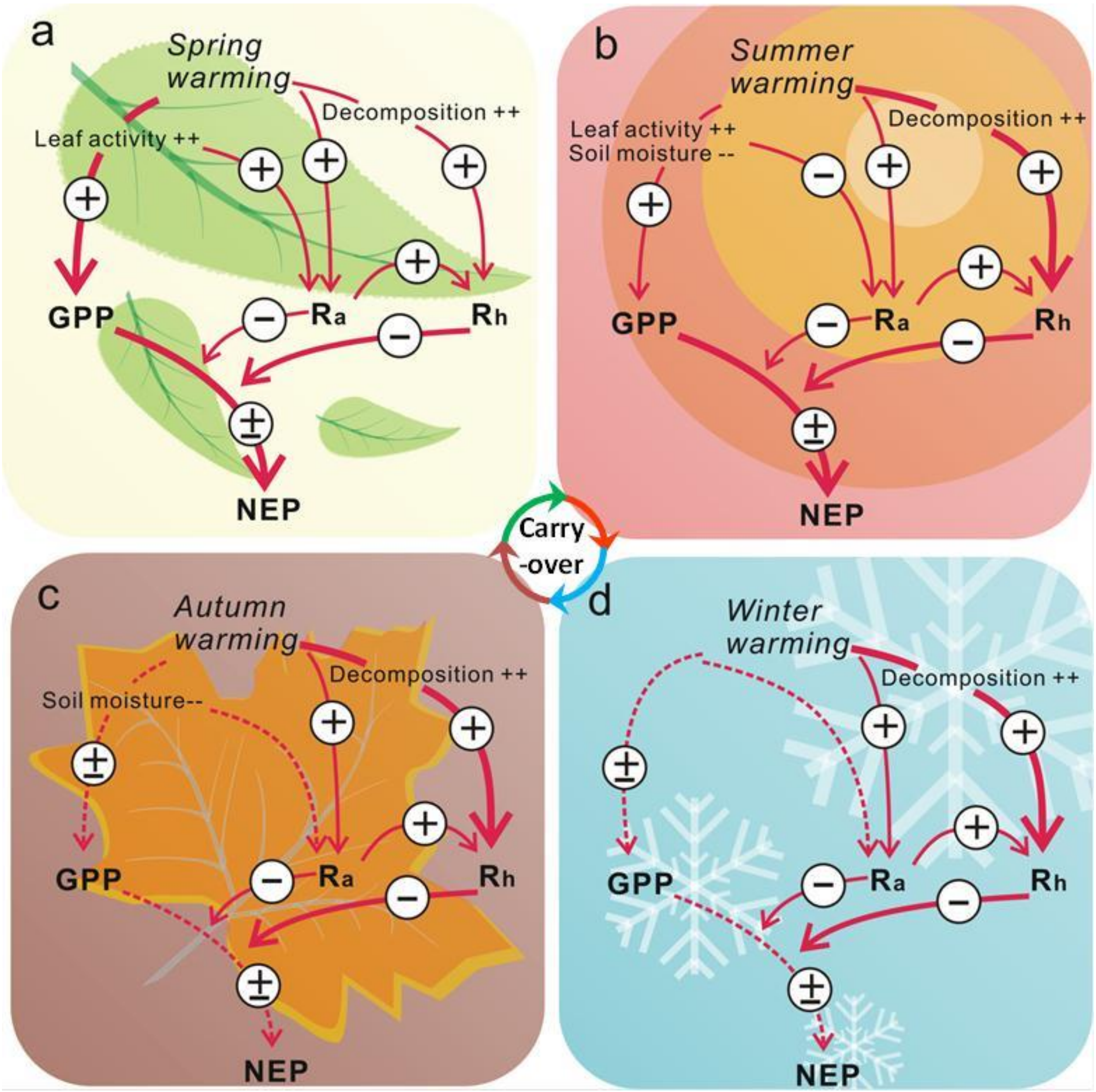
Global Perspective

Global NPP decreased from 2000 to 2009, with NPP over North Hemisphere continued increasing (winner) and over South Hemisphere decreased; Recent drying trend caused the reduction in NPP in SH.



Zhao & Running (2010). Science

Ecosystem NPP, R_a & R_h respiration, and NEP in response directly to global warming in (a) spring, (b) summer, (c) autumn, and (d) winter.



Xia et al. (Nature-Geoscience), 2014