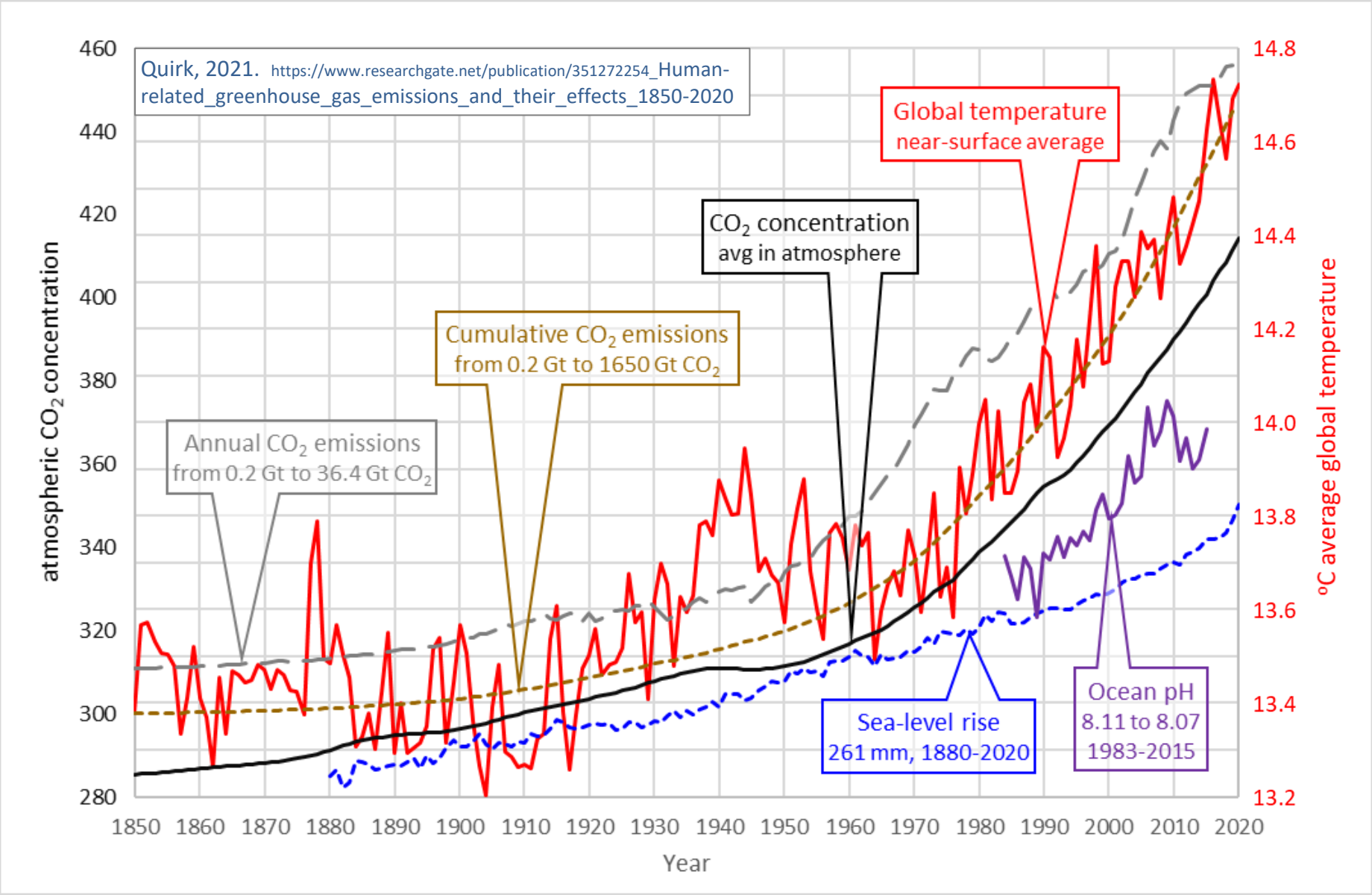
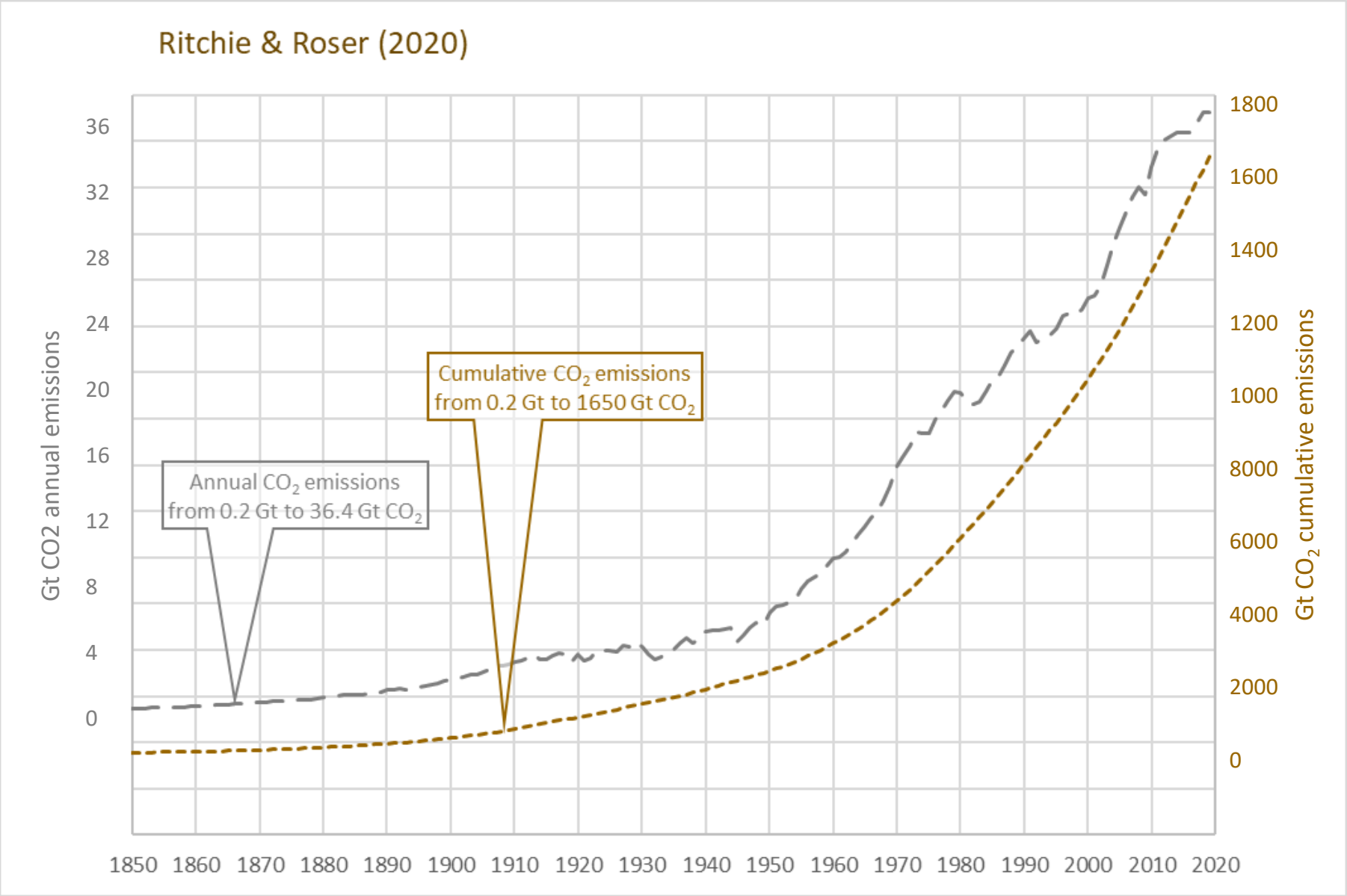
Human-related greenhouse gas emissions and their effects, 1850-2020



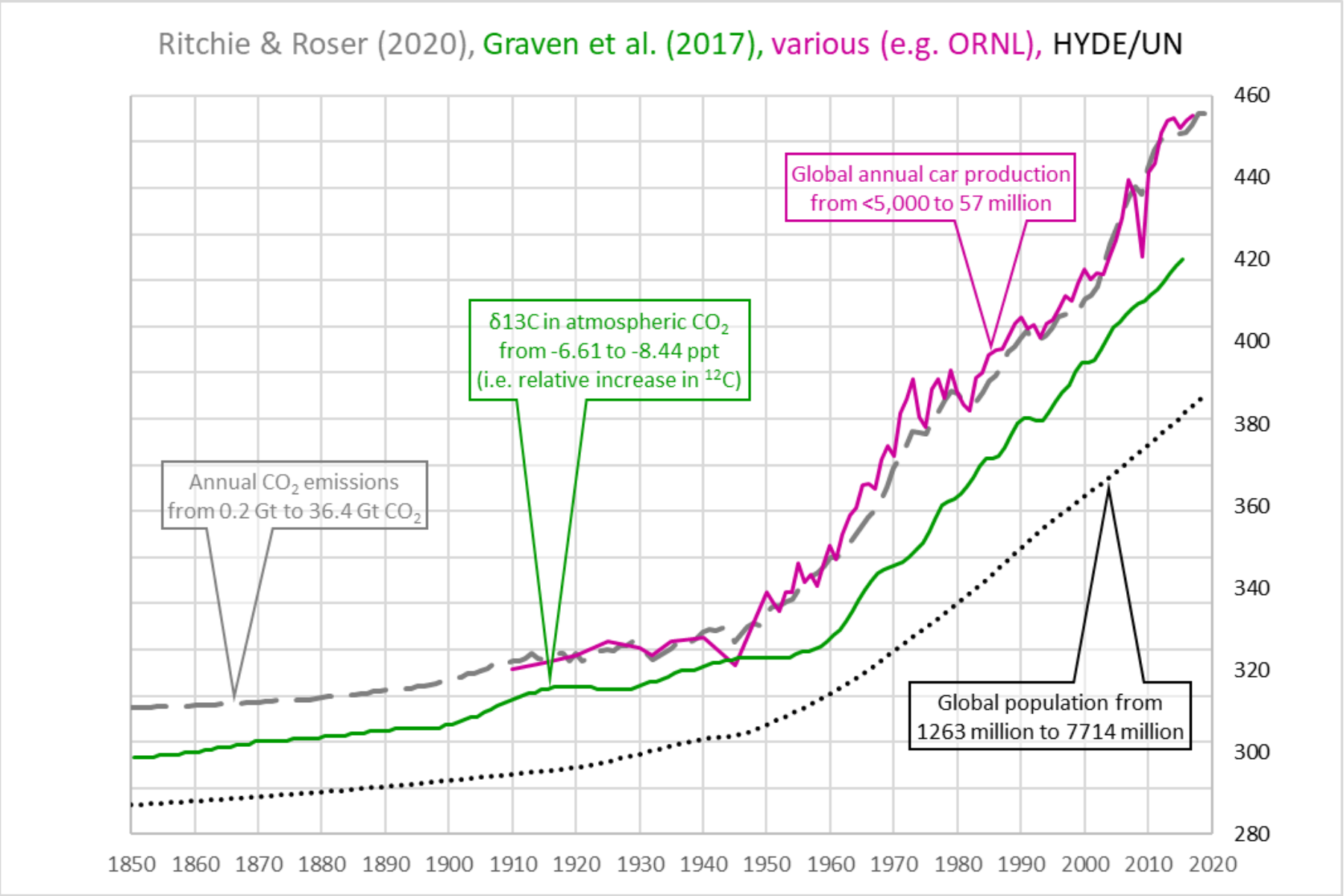
Data sources (Apr 2021): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit; US Environmental Protection Agency

1850-2020: CO_2 emissions



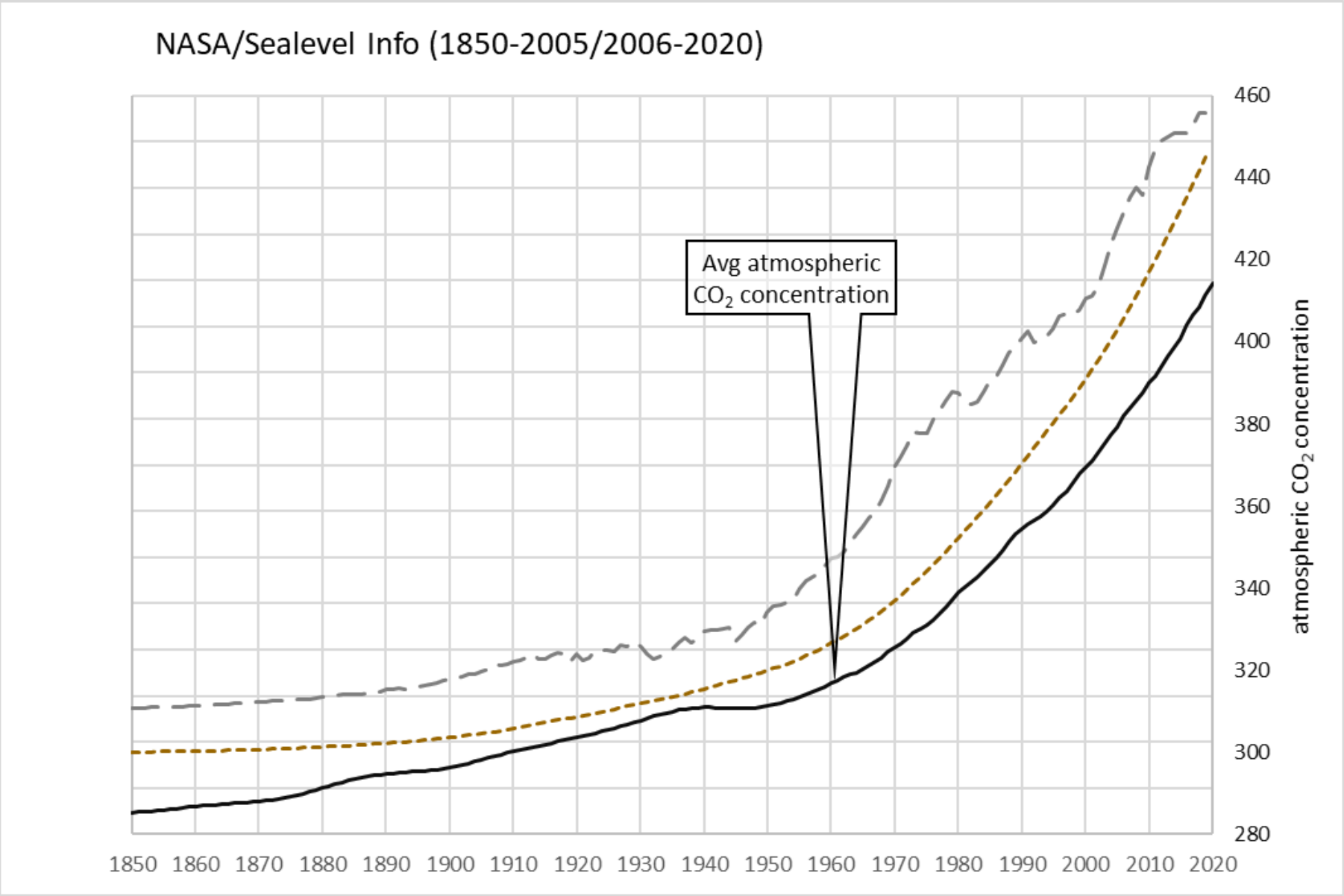
Data sources (Apr '21): Our World in Data after Global Carbon Project

Emissions correlate with burning of organic carbon & industrial activity



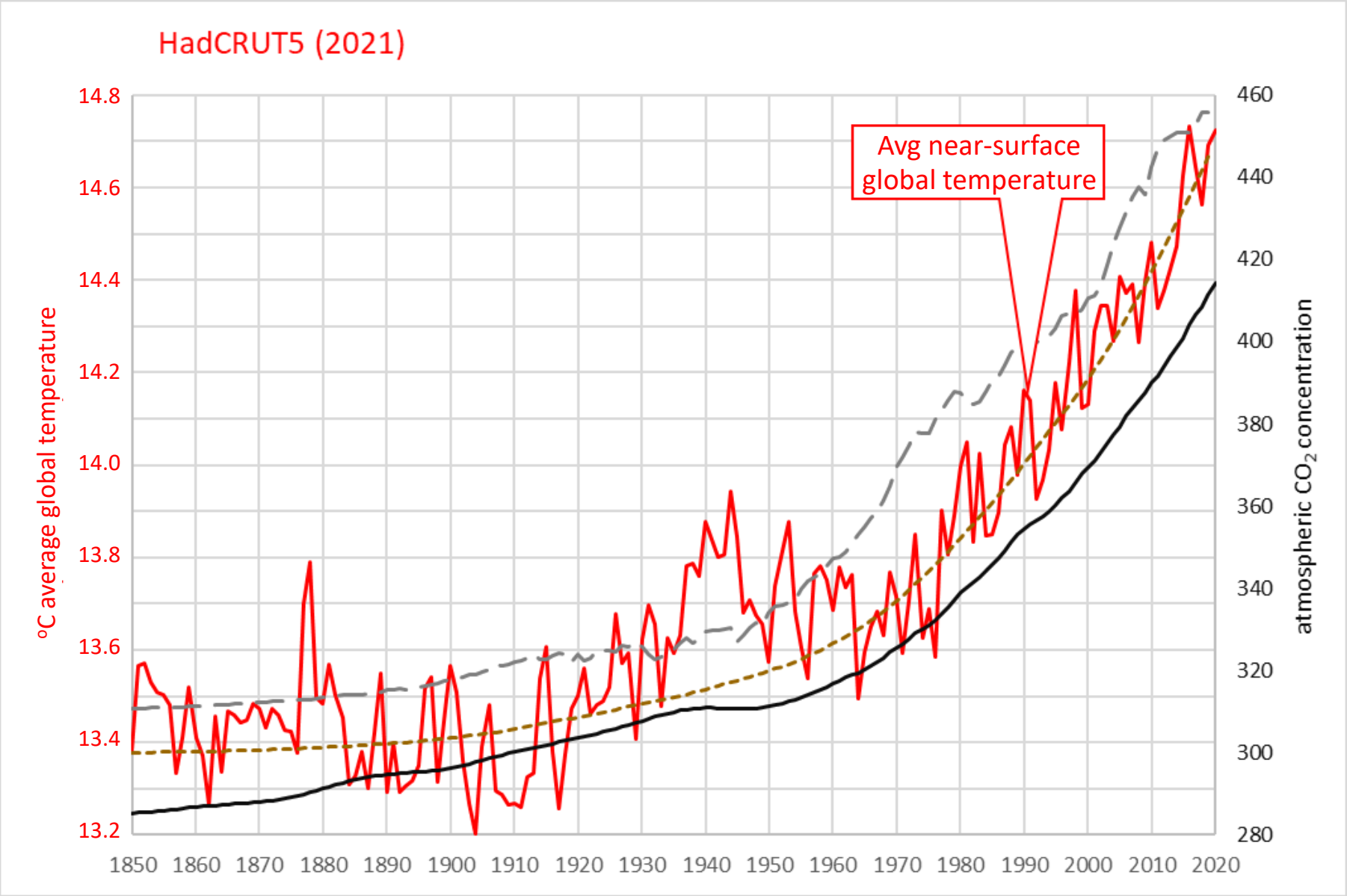
Data sources (Jun '21): Our World in Data after Global Carbon Project; Geoscientific Model Development; Oak Ridge National Laboratory / Bureau of Transport Statistics / Renner, 2008 / Qualmann, 2017; Klein Goldewijk et al., 2010 / UN, 2019

1850-2020: CO_2 emissions, atmospheric [CO_2]



Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info

1850-2020: CO_2 emissions, atmospheric [CO_2], global temperature

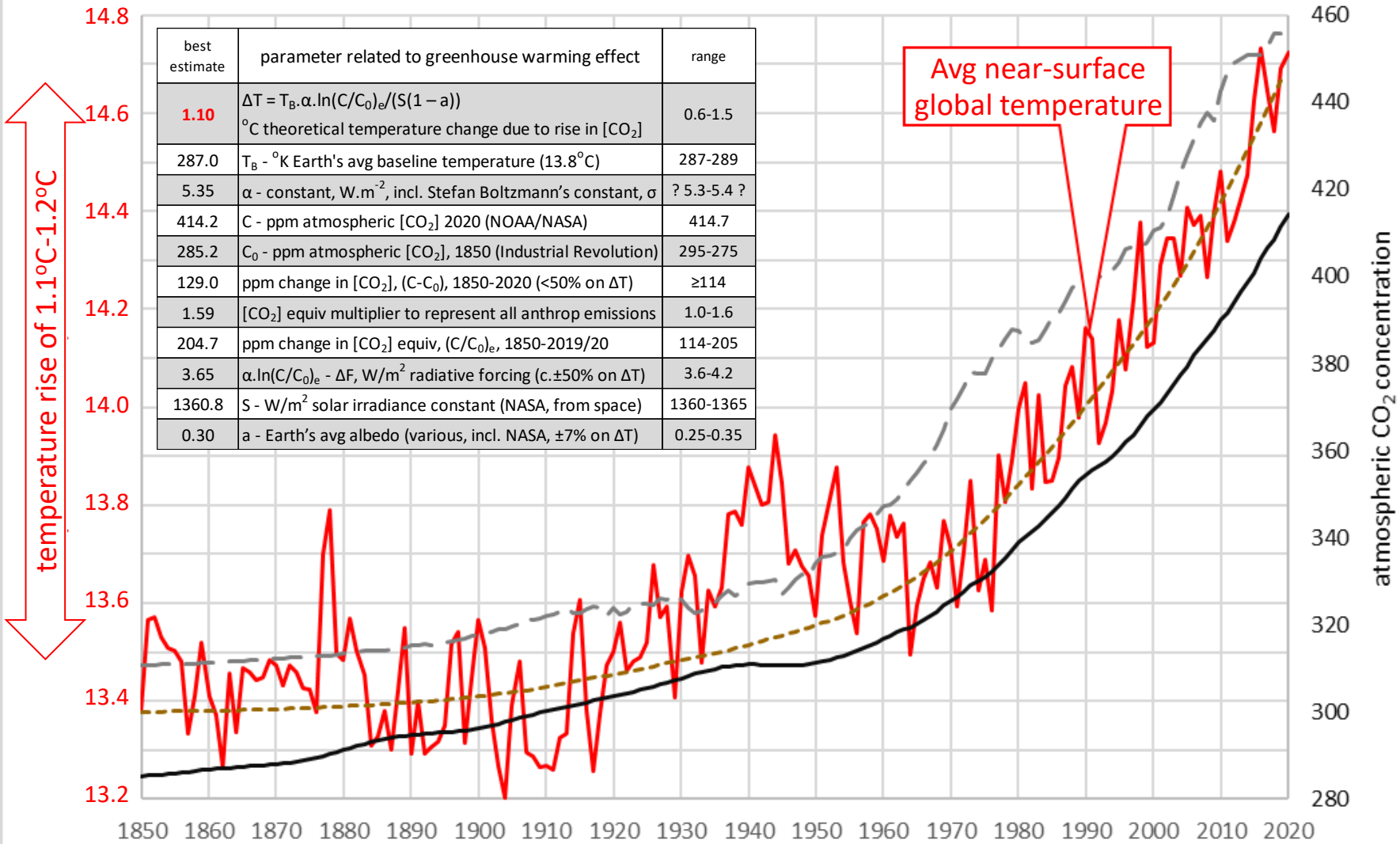


Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit

Predictable warming due to radiative forcing (e.g. Arrhenius, 1896)

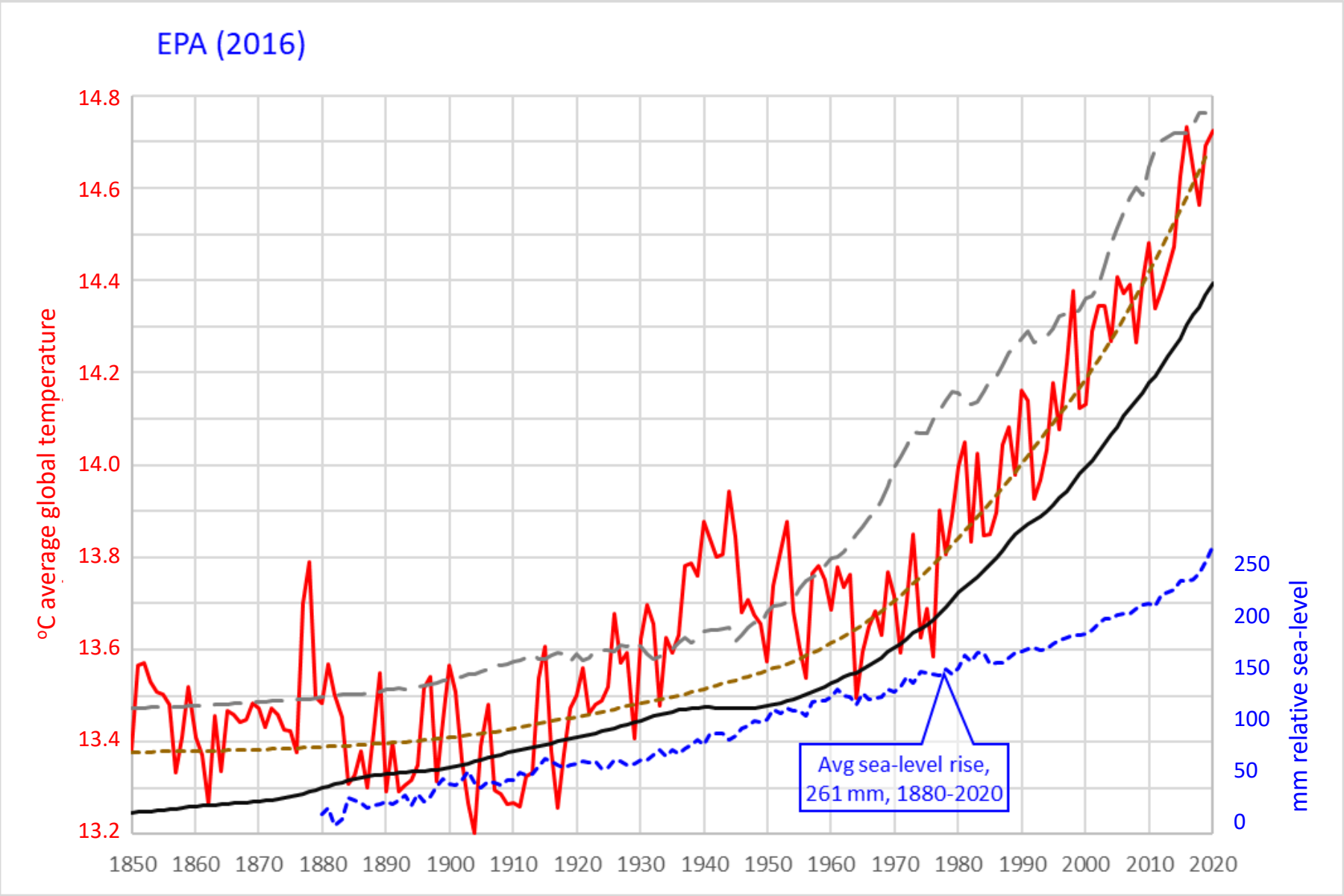
- GHGs absorb infra-red energy that would otherwise be lost to space

best estimate	parameter related to greenhouse warming effect	range
1.10	$\Delta T = T_B.\alpha.\ln(C/C_0)_e/(S(1-a))$ °C theoretical temperature change due to rise in $[CO_2]$	0.6-1.5
287.0	T_B - °K Earth's avg baseline temperature (13.8°C)	287-289
5.35	α - constant, $W.m^{-2}$, incl. Stefan Boltzmann's constant, σ	? 5.3-5.4 ?
414.2	C - ppm atmospheric $[CO_2]$ 2020 (NOAA/NASA)	414.7
285.2	C_0 - ppm atmospheric $[CO_2]$, 1850 (Industrial Revolution)	295-275
129.0	ppm change in $[CO_2]$, $(C-C_0)$, 1850-2020 (<50% on ΔT)	≥114
1.59	$[CO_2]$ equiv multiplier to represent all anthrop emissions	1.0-1.6
204.7	ppm change in $[CO_2]$ equiv, $(C/C_0)_e$, 1850-2019/20	114-205
3.65	$\alpha.\ln(C/C_0)_e$ - ΔF, W/m^2 radiative forcing (c.±50% on ΔT)	3.6-4.2
1360.8	S - W/m^2 solar irradiance constant (NASA, from space)	1360-1365
0.30	a - Earth's avg albedo (various, incl. NASA, ±7% on ΔT)	0.25-0.35



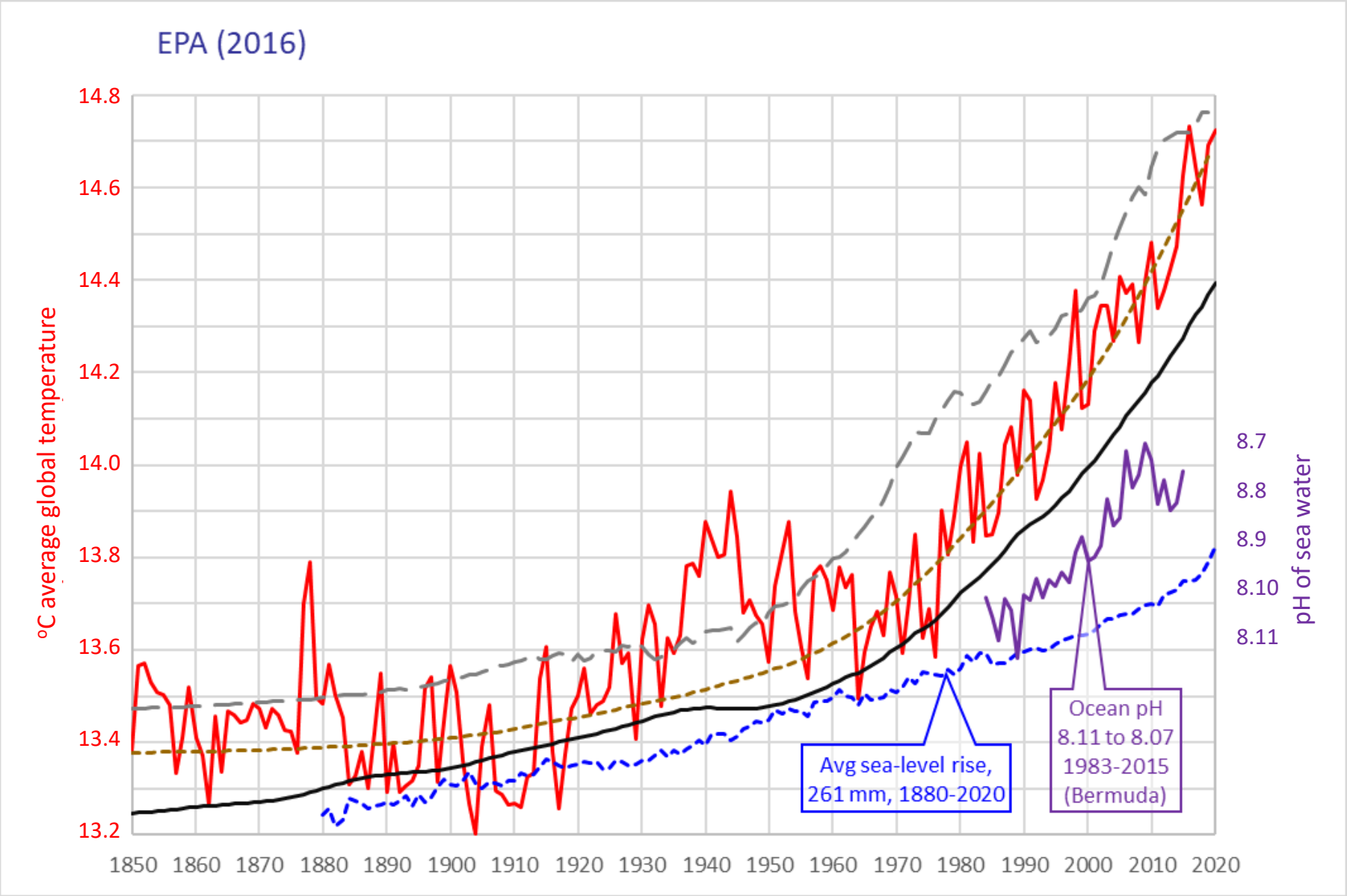
Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit

Melting of land-based ice & warming of oceans cause sea-level rise



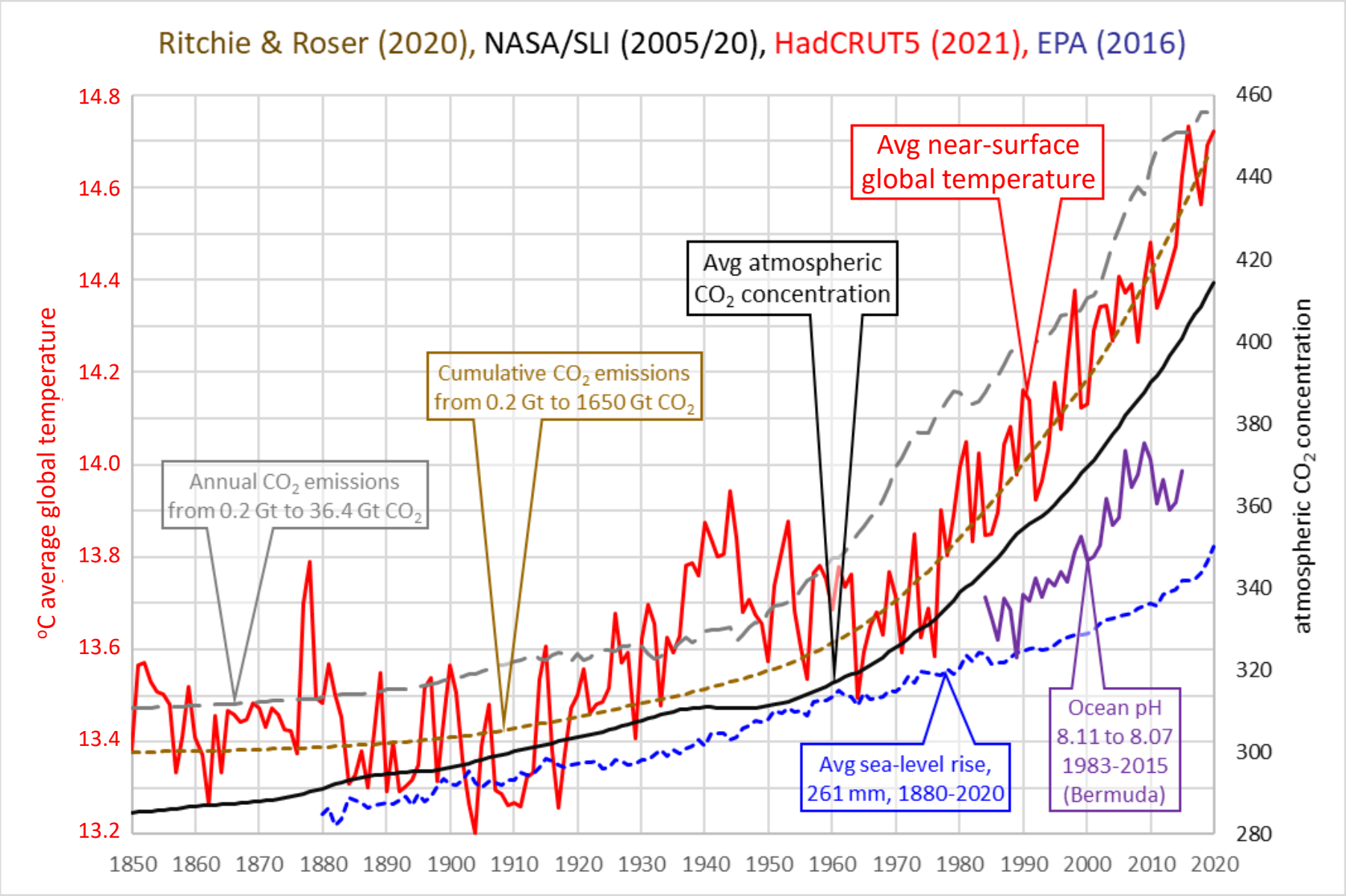
Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit; US Environmental Protection Agency

Absorption of excess CO_2 by sea water leads to ocean acidification



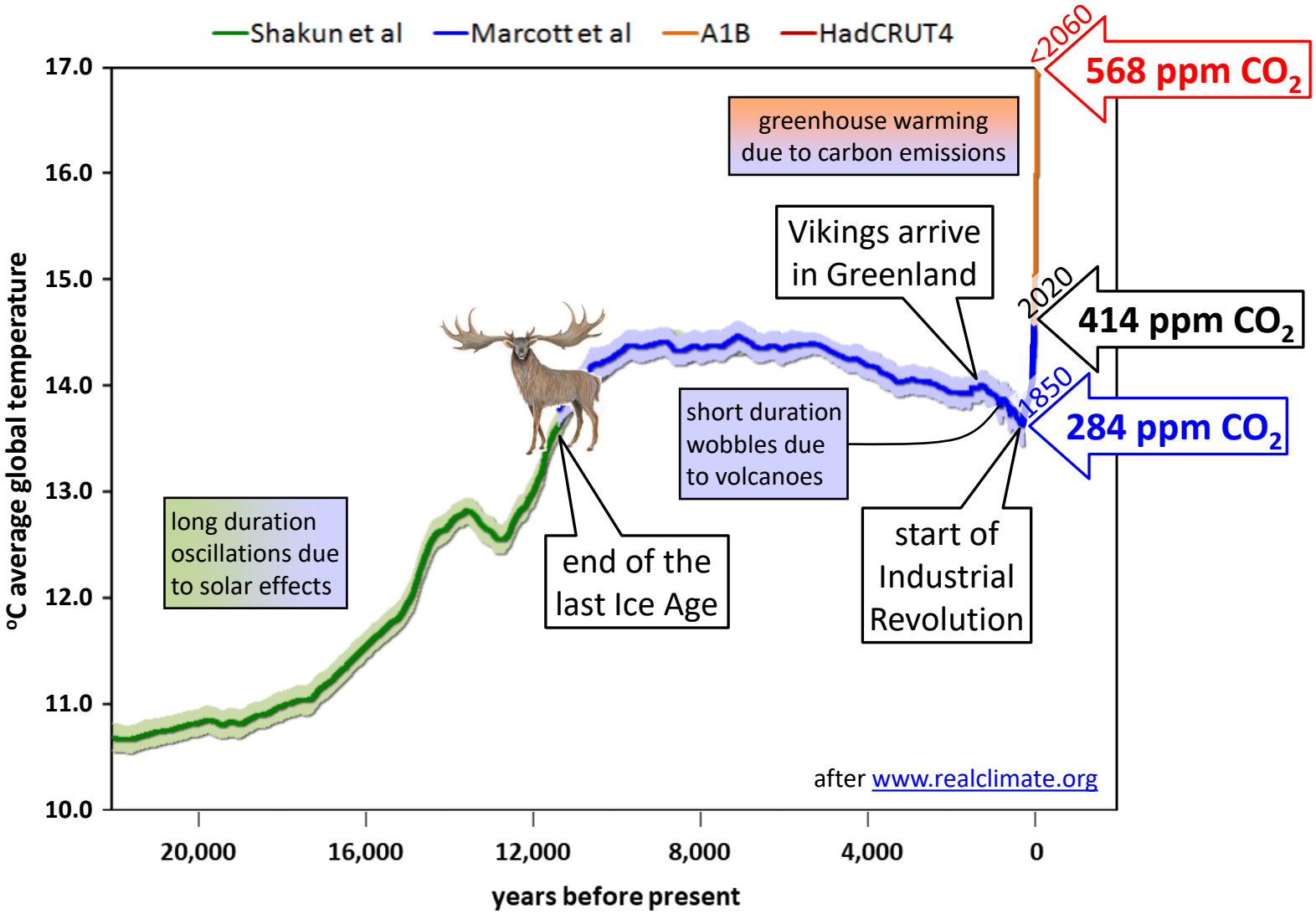
Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit; US Environmental Protection Agency

1850-2020: CO_2 emissions, atmosp [CO_2], global temp, sea-level & pH

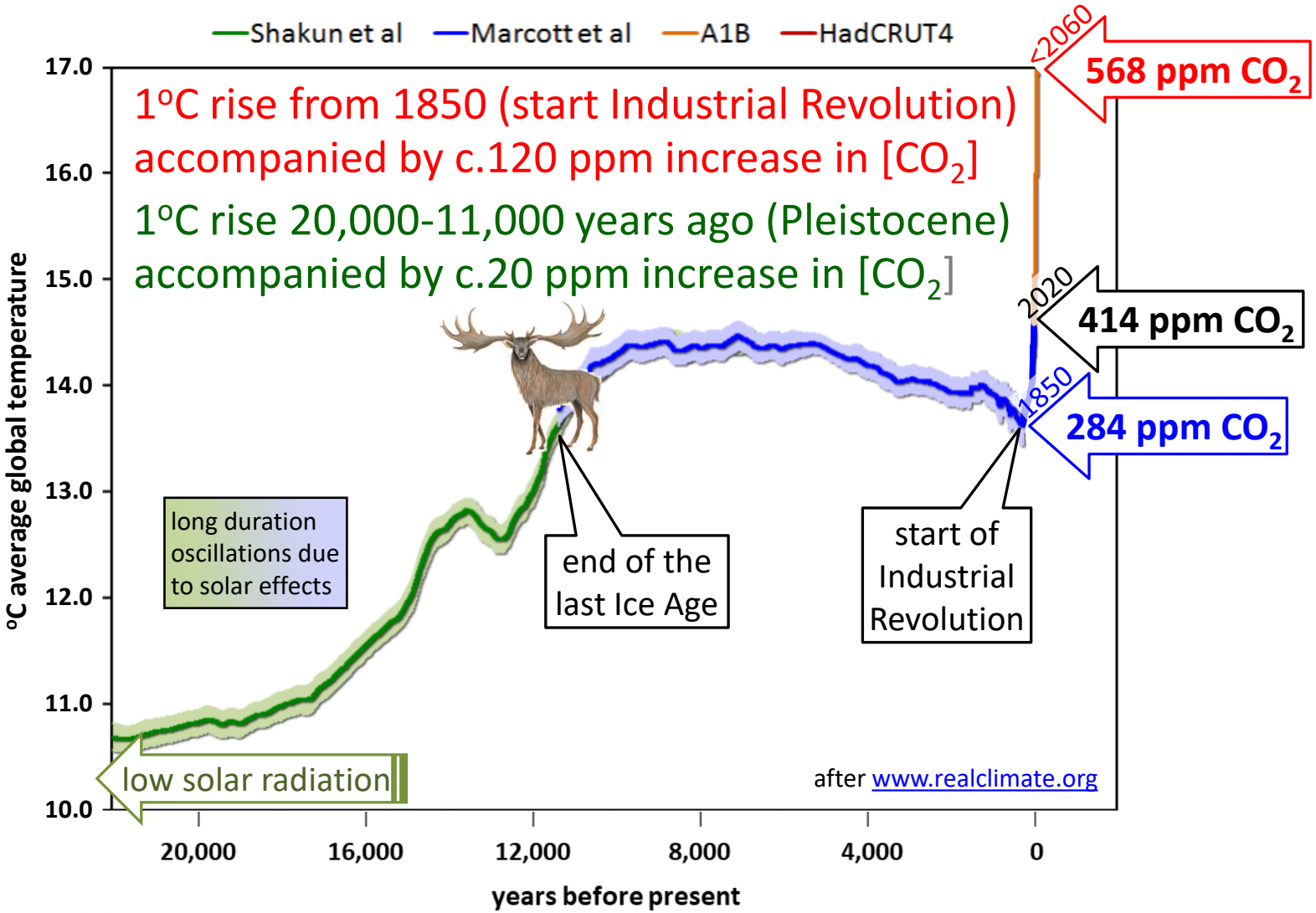


Data sources (Apr '21): Our World in Data after Global Carbon Project; NASA Goddard Institute for Space Studies + www. sealevel.info; Hadley Centre & UEA Climate Research Unit; US Environmental Protection Agency

Historical change in global temperature + future projections



Historical change in global temperature + future projections



Reference: Quirk, D.G., 2021. *Human-related greenhouse gas emissions and their effects, 1850-2020*. DOI: 10.13140/RG.2.2.11432.49921.
Document can be accessed via www.energysustainabilitycentre.im/knowledge-hub.
For further information please contact Dave Quirk at geologicalsurvey@manx.net.

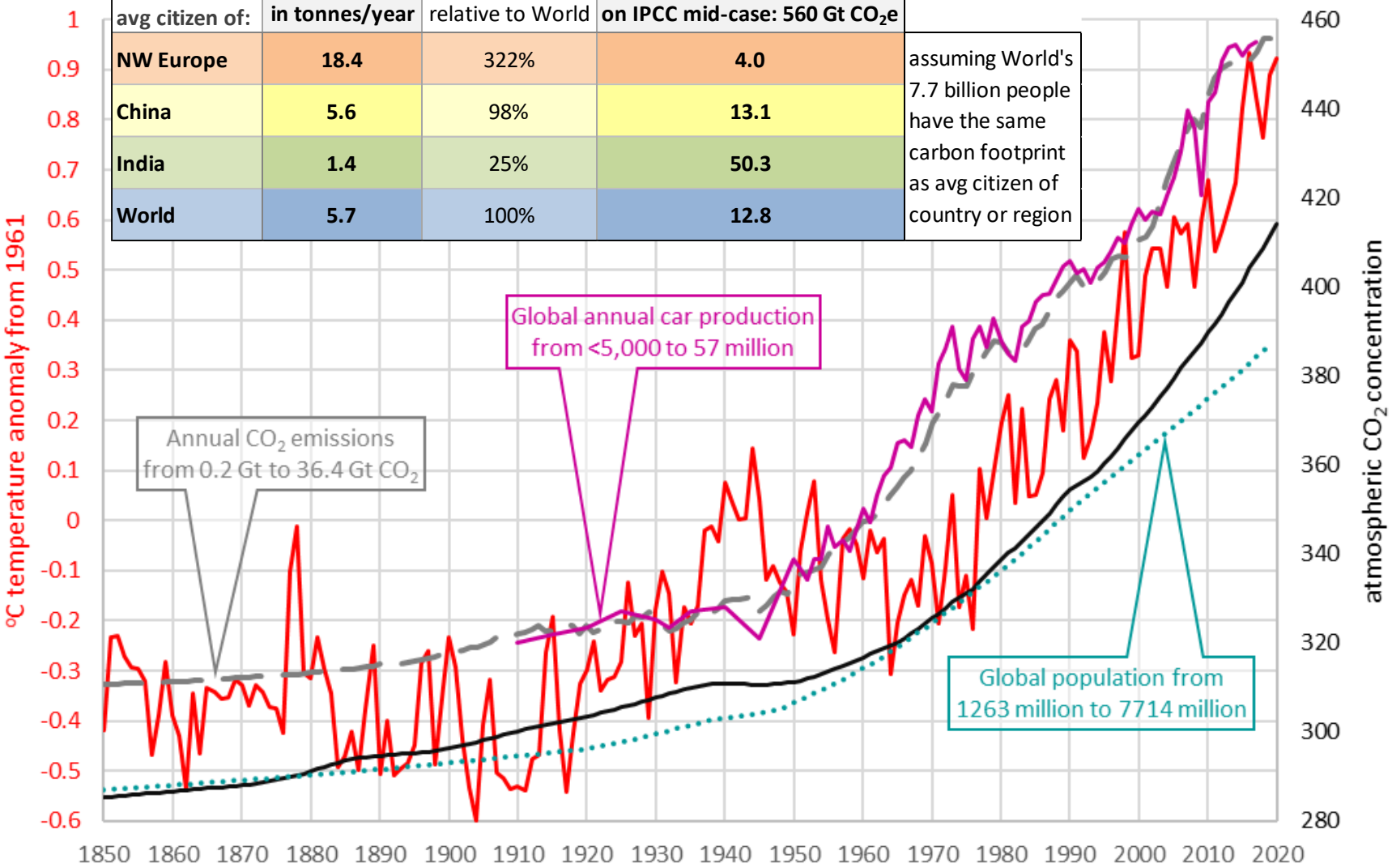
Energy and Sustainability Centre, IoM

Manx Geological Survey

Unequal emissions: consumption in developed countries is not sustainable

avg citizen of:	CO_2e emissions per avg citizen in tonnes/year	CO_2e emissions per avg citizen relative to World	Years equivalent to 1.5°C global temperature rise based on IPCC mid-case: 560 Gt CO_2e
NW Europe	18.4	322%	4.0
China	5.6	98%	13.1
India	1.4	25%	50.3
World	5.7	100%	12.8

assuming World's 7.7 billion people have the same carbon footprint as avg citizen of country or region



Data sources (Apr-Jun '21): Tukker et al., 2014 (table), Our World in Data; Oak Ridge Natnl Lab / Bureau of Transport Stats / Renner, 2008 / Qualmann, 2017; NASA Goddard Institute; Hadley Centre & UEA Climate Research Unit; Klein Goldewijk et al., 2010 / UN, 2019