Impact van het OK op het klimaat

Belgian Association for Ambulatory Surgery

05-13-2023

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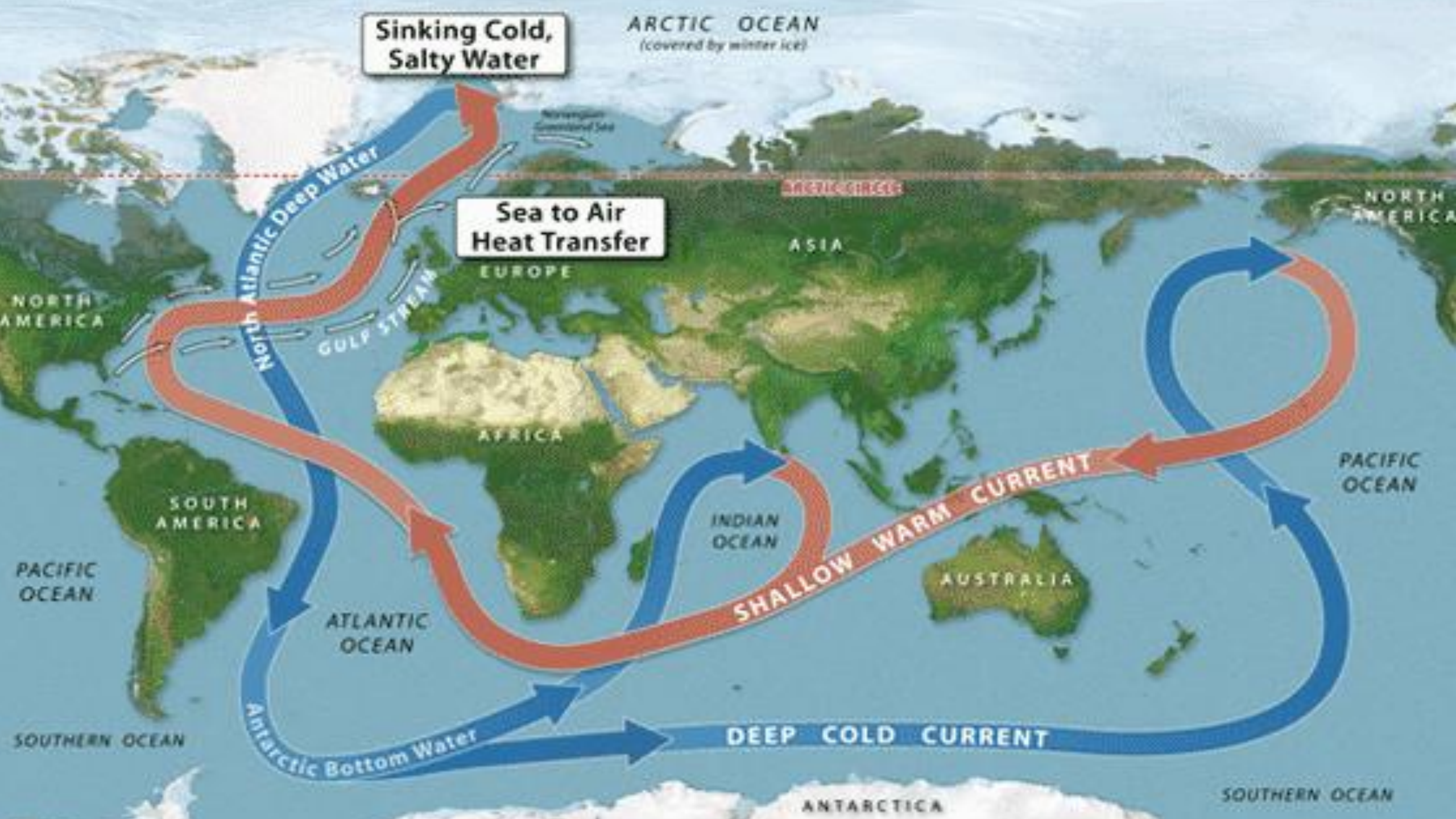
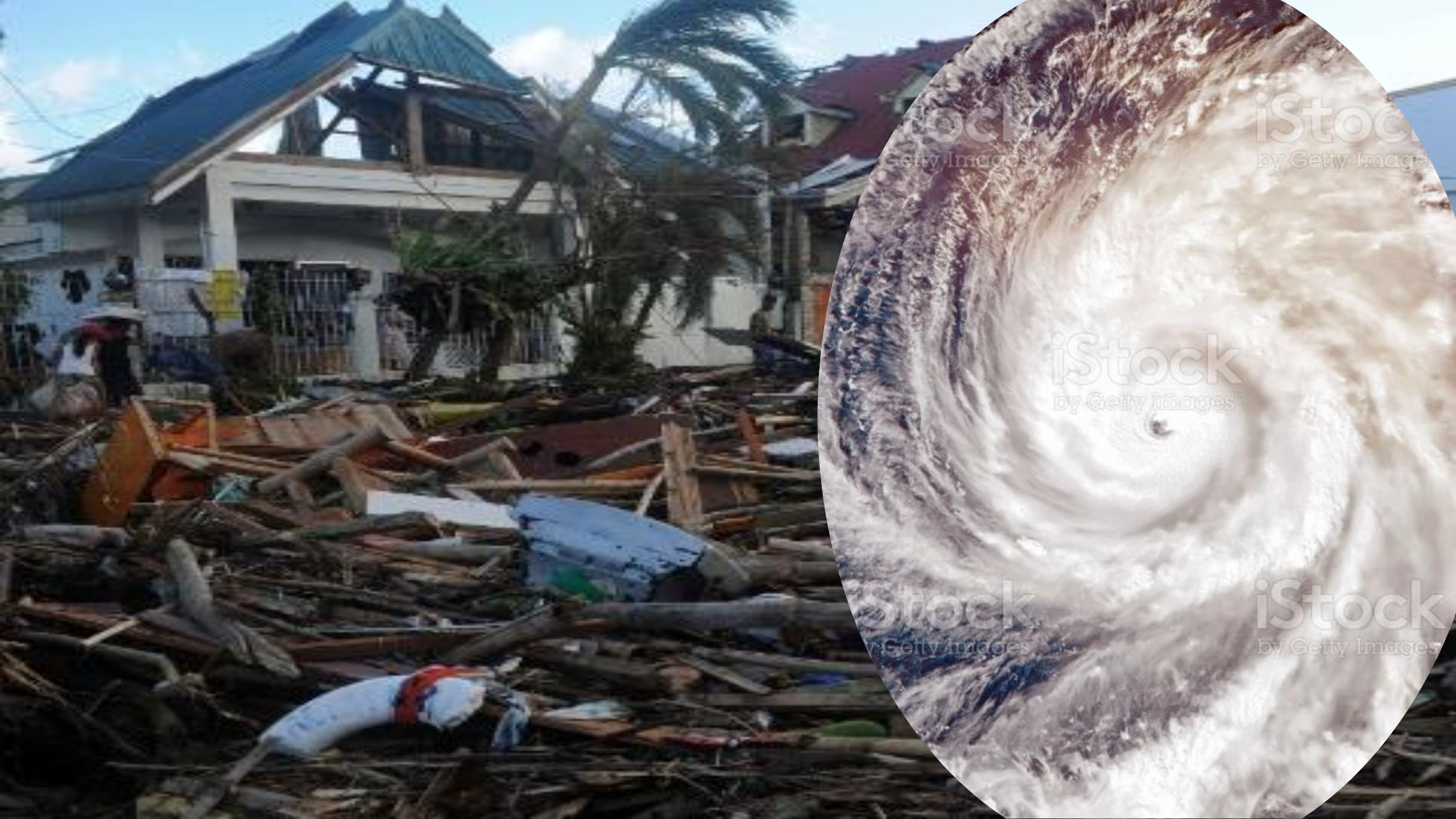
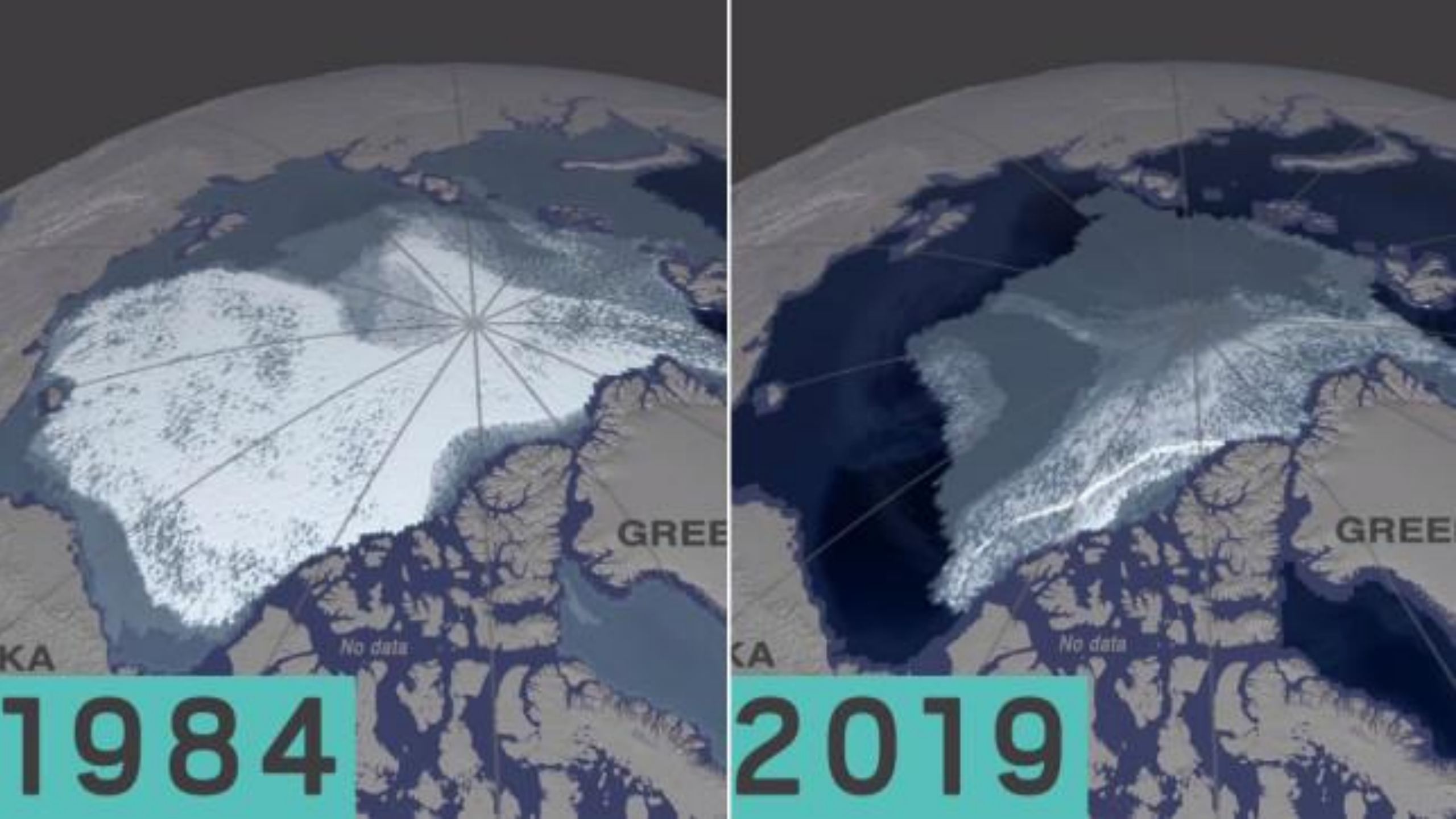
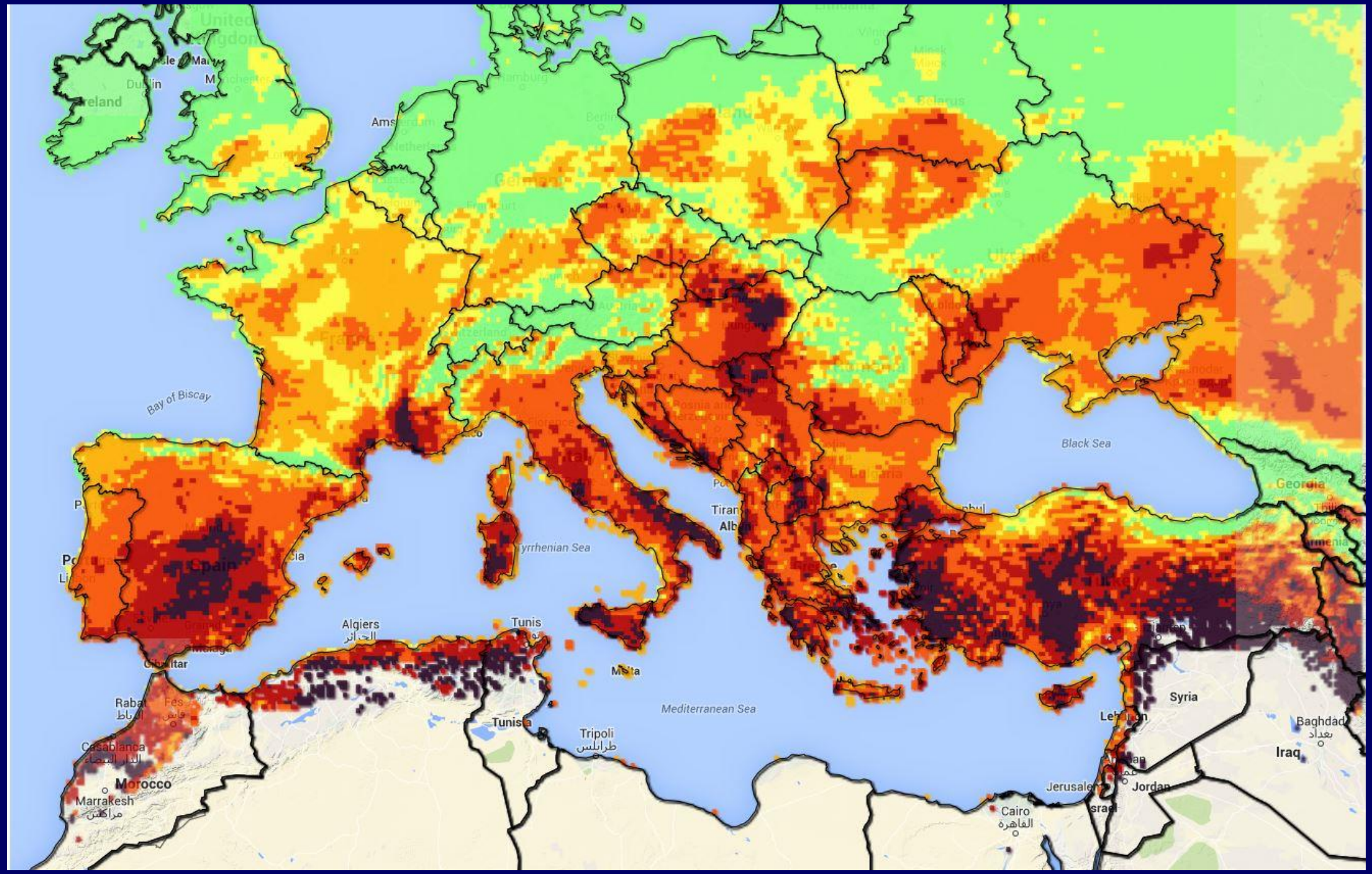
Brugge, Belgium


Sinking Cold, Salty Water
ARCTIC OCEAN
(covered by winter ice)
North Atlantic Deep Water
Sea to Air Heat Transfer
EUROPE
ASIA
NORTH AMERICA
GULF STREAM
AFRICA
SOUTH AMERICA
PACIFIC OCEAN
INDIAN OCEAN
ATLANTIC OCEAN
AUSTRALIA
SHALLOW WARM CURRENT
Antarctic Bottom Water
DEEP COLD CURRENT
SOUTHERN OCEAN
ANTARCTICA

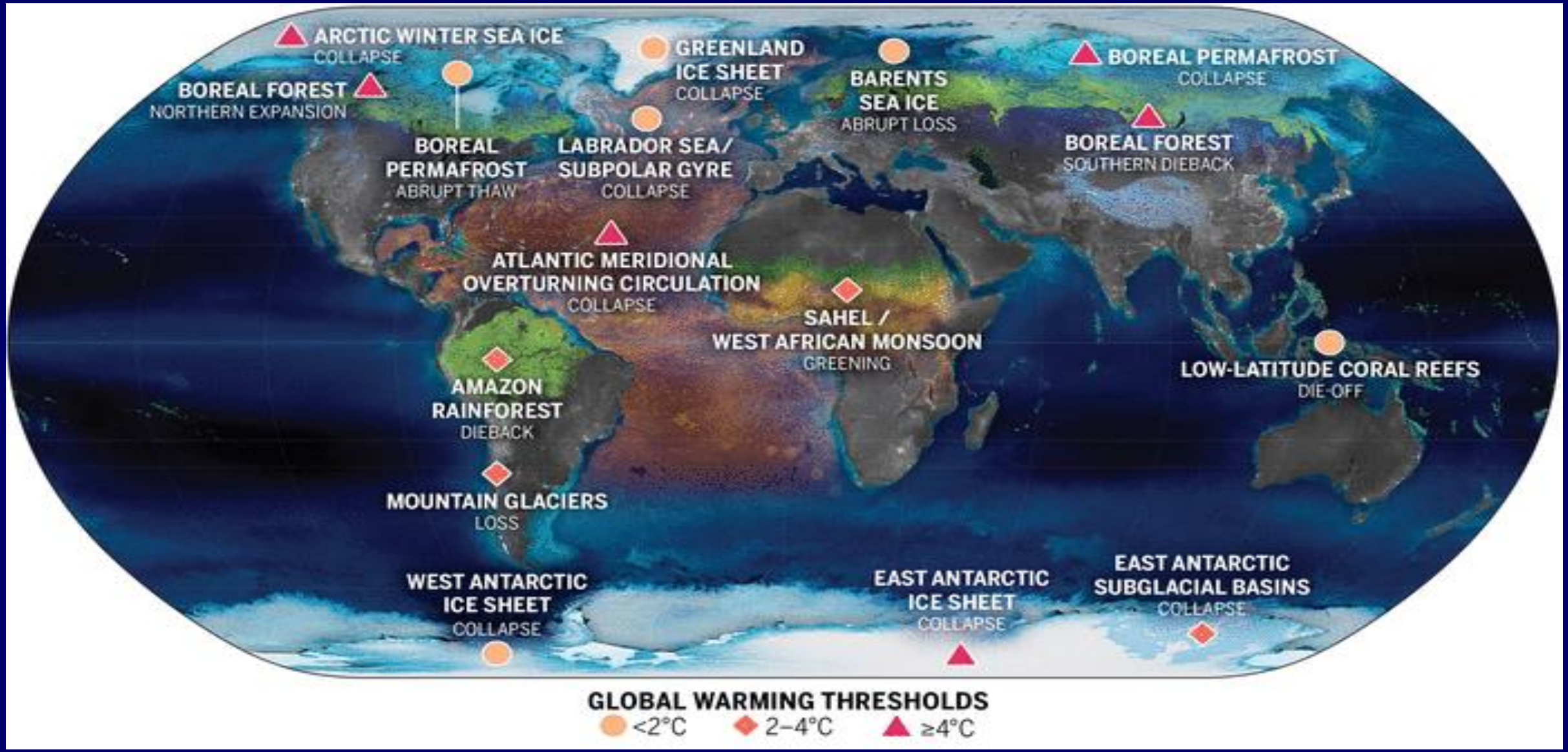



GREE
No data
1984
GREE
No data
2019


Bay of Biscay
Black Sea
Tyrrhenian Sea
Mediterranean Sea
Spain
Morocco
Algiers
Tunis
Tunisia
Tripoli
Malta
Gibraltar
Rabat
Fes
Casablanca
Marrakesh
Syria
Iraq
Baghdad
Jordan
Jerusalem
Cairo
Georgia
Dublin
Amsterdam

2° warming …

Tipping points



Exceeding 1.5°C global warming could trigger multiple climate tipping points, 2022 Volume: 377, Issue: 6611, DOI: (10.1126/science.abn7950)

SCIENTIFIC AMERICAN®

We Are Living in a Climate Emergency, and We're Going to Say So

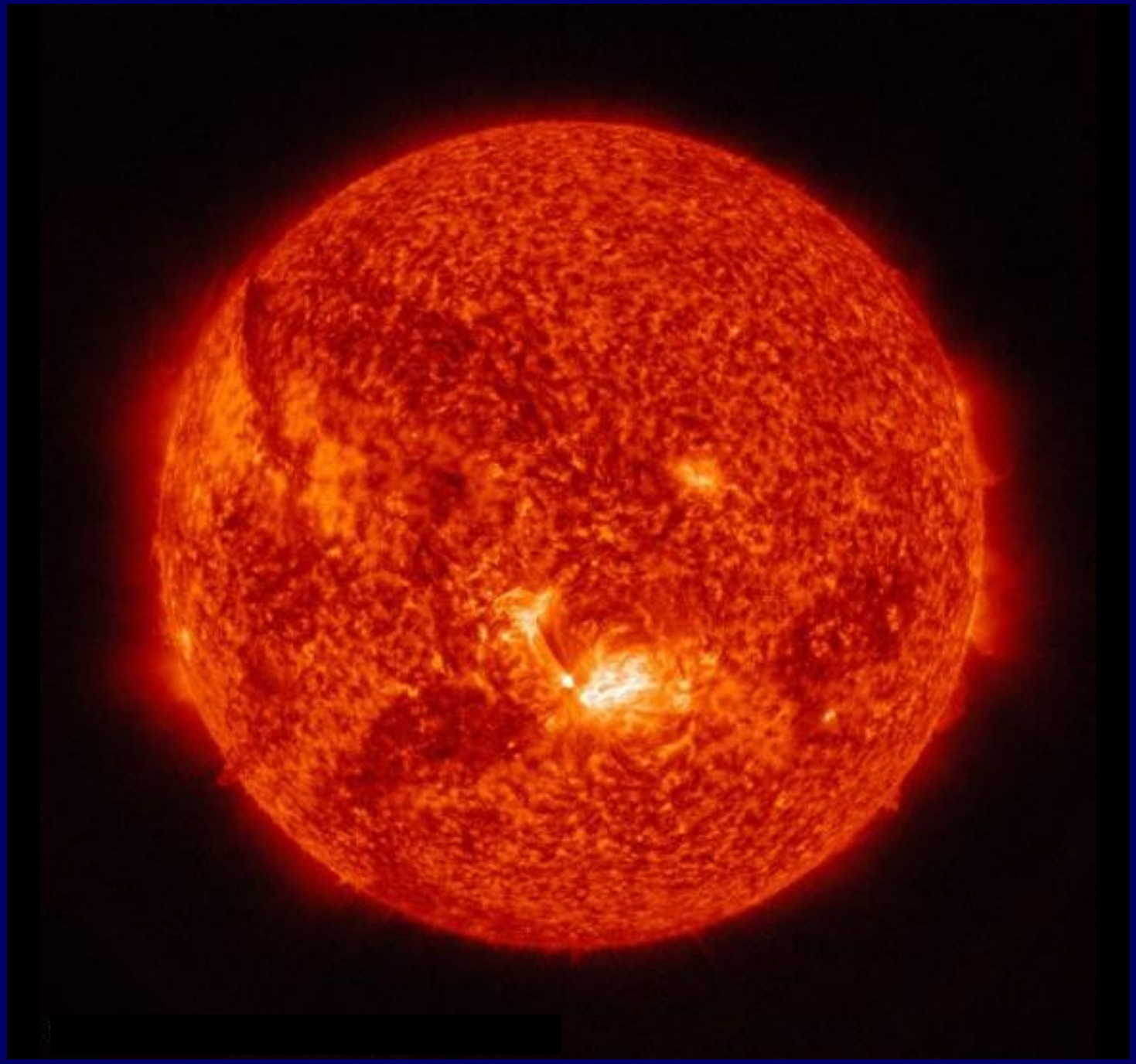
It's time to use a term that more than 13,000 scientists agree is needed

By Mark Fischetti on April 12, 2021

?

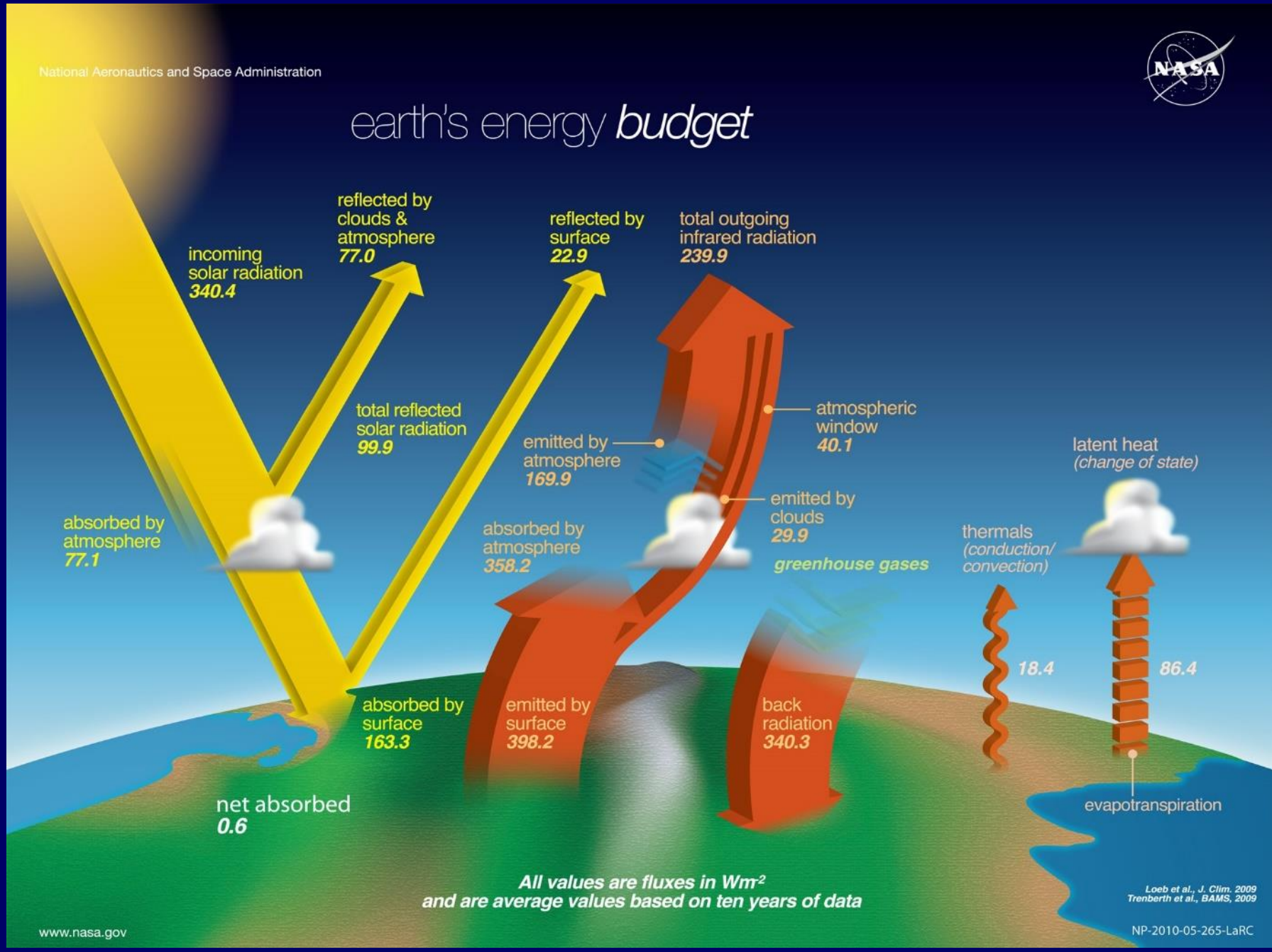
2,7 K = -270°C

5778 K



+123°C

-153°C


National Aeronautics and Space Administration
NASA
earth's energy budget
incoming solar radiation 340.4
reflected by clouds & atmosphere 77.0
reflected by surface 22.9
total outgoing infrared radiation 239.9
total reflected solar radiation 99.9
atmospheric window 40.1
emitted by atmosphere 169.9
emitted by clouds 29.9
greenhouse gases
absorbed by atmosphere 77.1
absorbed by atmosphere 358.2
latent heat (change of state)
thermals (conduction/ convection)
18.4
86.4
absorbed by surface 163.3
emitted by surface 398.2
back radiation 340.3
evapotranspiration
net absorbed 0.6
All values are fluxes in Wm-2
and are average values based on ten years of data
Loeb et al., J. Clim. 2009
Trenberth et al., BAMS, 2009
www.nasa.gov
NP-2010-05-265-LaRC

- **Equilibrium : energy in = energy out**

- **Today :** In: 340.0 W/m²
  Out: -338.36 W/m²
  1.64 W/m²

1.5 million km

Nature Geoscience. **5** (10): 691–696.

Total solar energy in : 173,000 TW

Heat absorption : 836 TW

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= 46 times the Total energy use of humanity (18TW)

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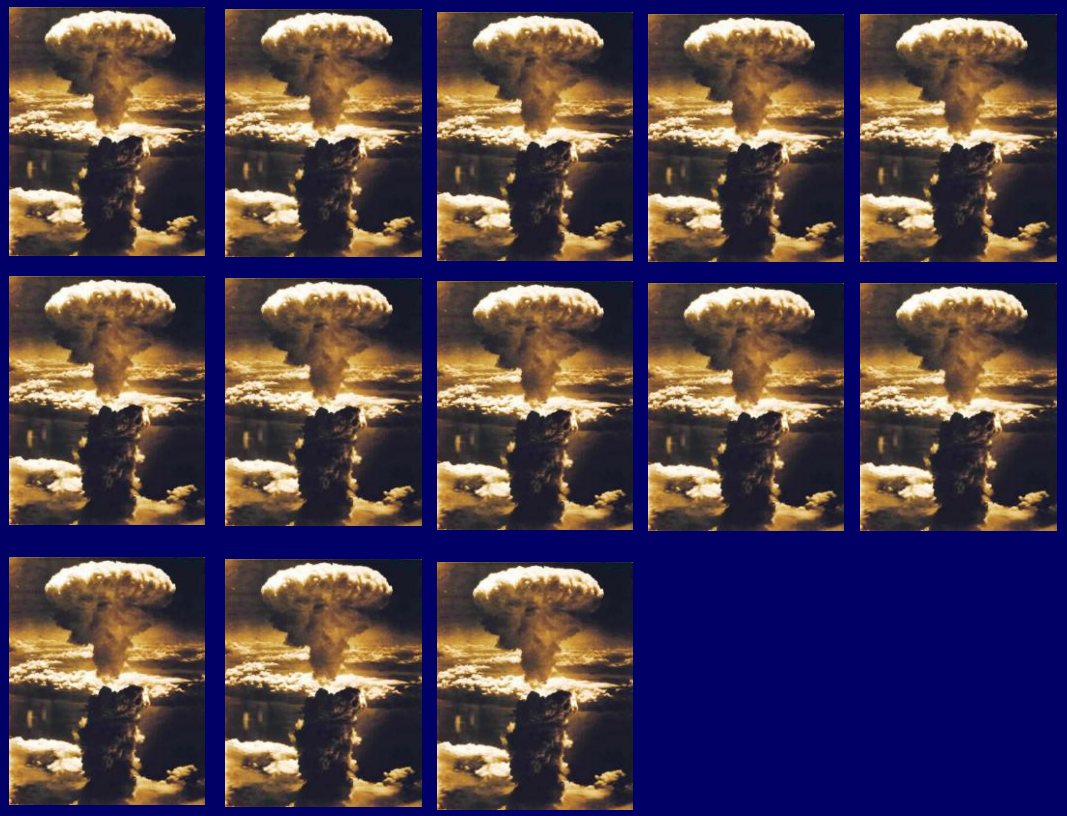
=  every second

1 Hiroshima bomb = 63 TJ

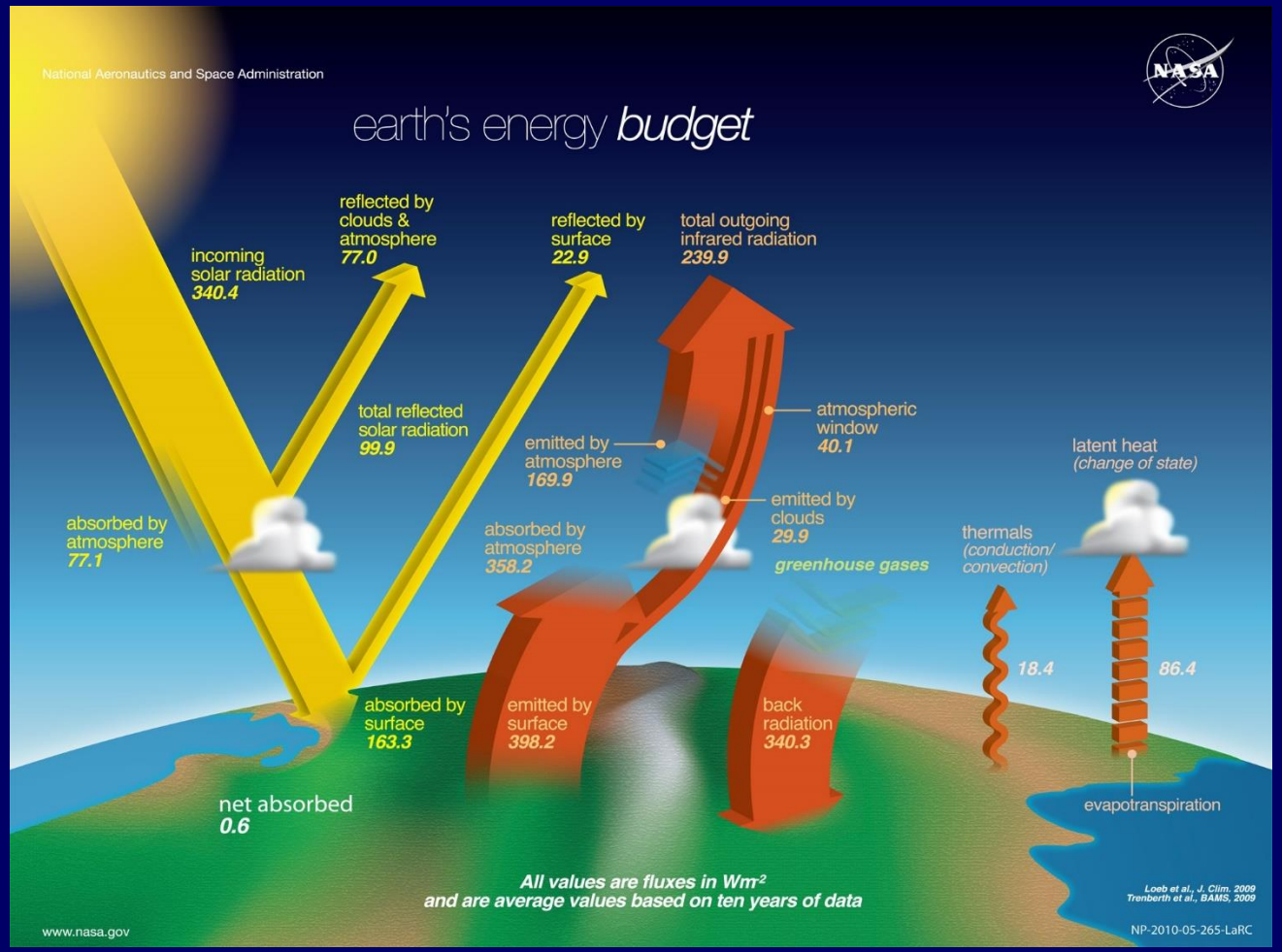
This is

NOT Sustainable

Impact of medicine? volatile anesthetics?

Global Warming Potential GWP

- **Relative value**
- **GWP:**
  "heating potential in a given period of 1 kg of a gas relative to 1 kg of CO_2"



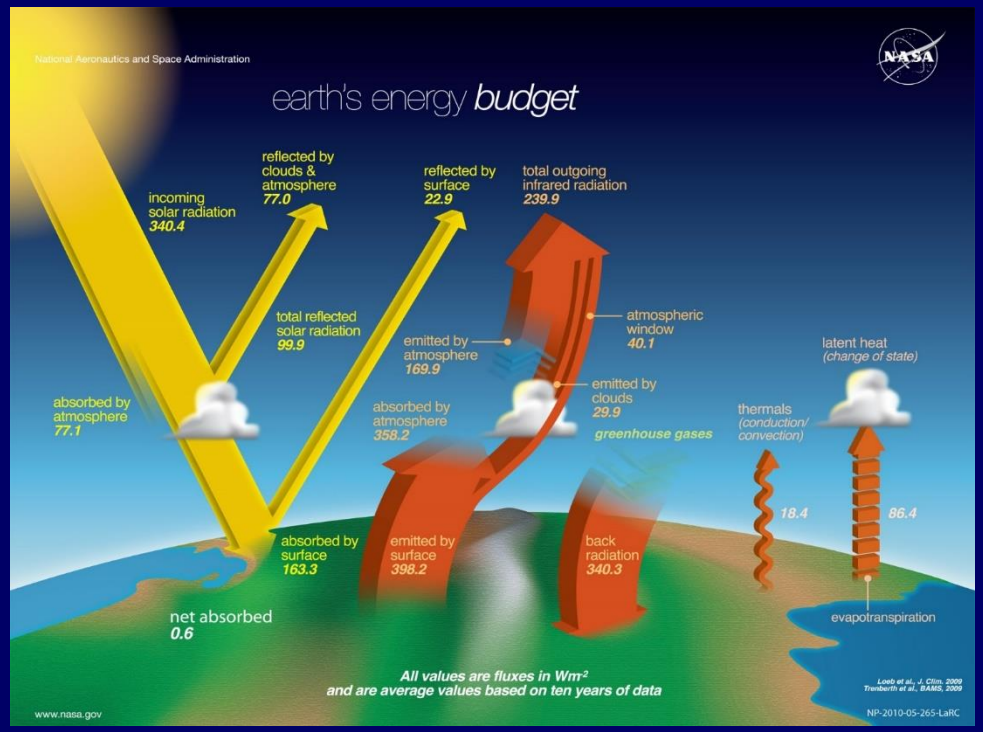
Global Warming Potential GWP

Molecule	GWP (100y)
CO_2	1
CH_4	28
N_2O	265
SF_6 (sulfur hexafluoride)	23.500

Determinants
GWP

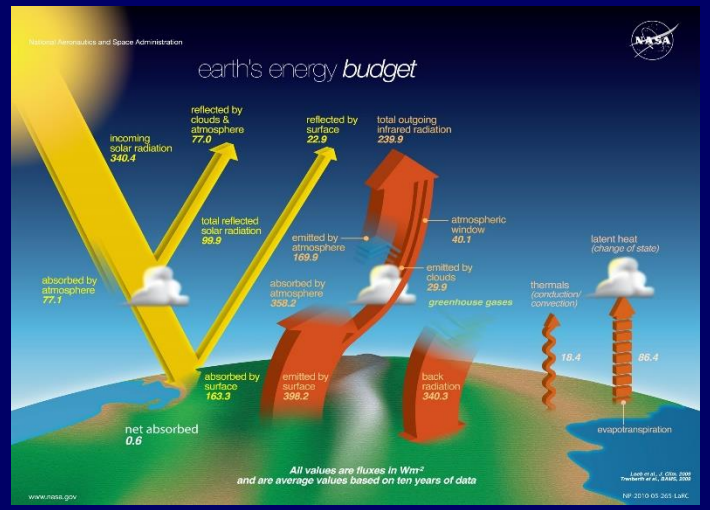
1. Added Absorption spectrum in IR-range

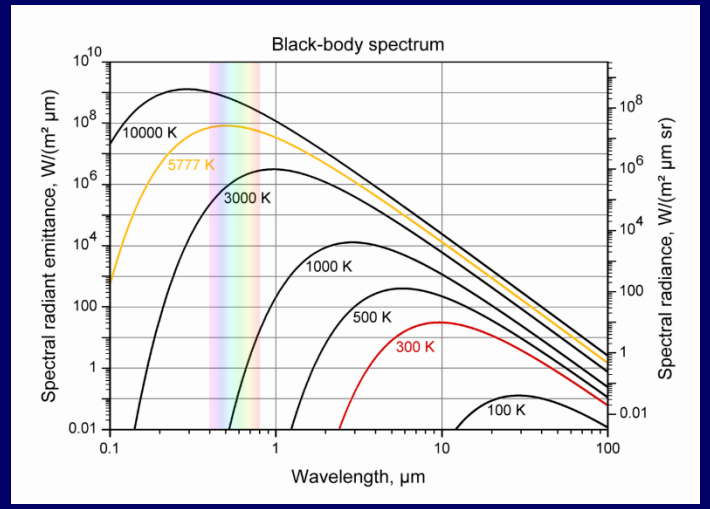
2. Atmospheric half-life

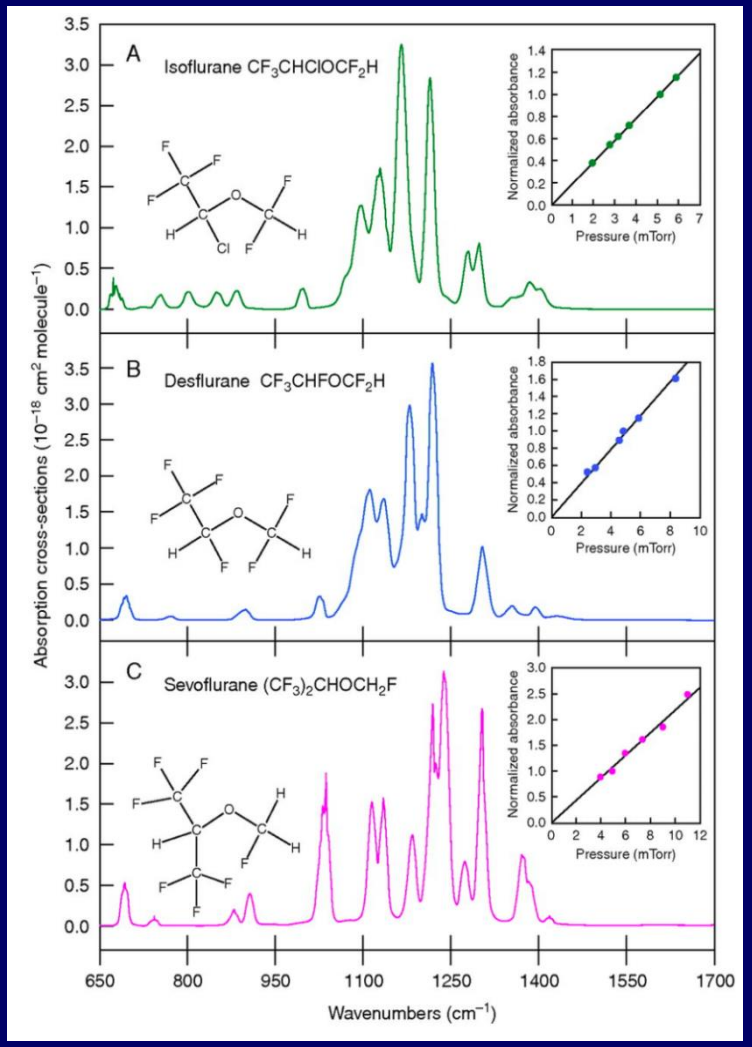


GWP

1. IR-Absorption spectrum







Isoflurane

Desflurane

Sevoflurane

Inhalation anaesthetics and climate change.
Br J Anaesth. 2010; 105: 760-6.

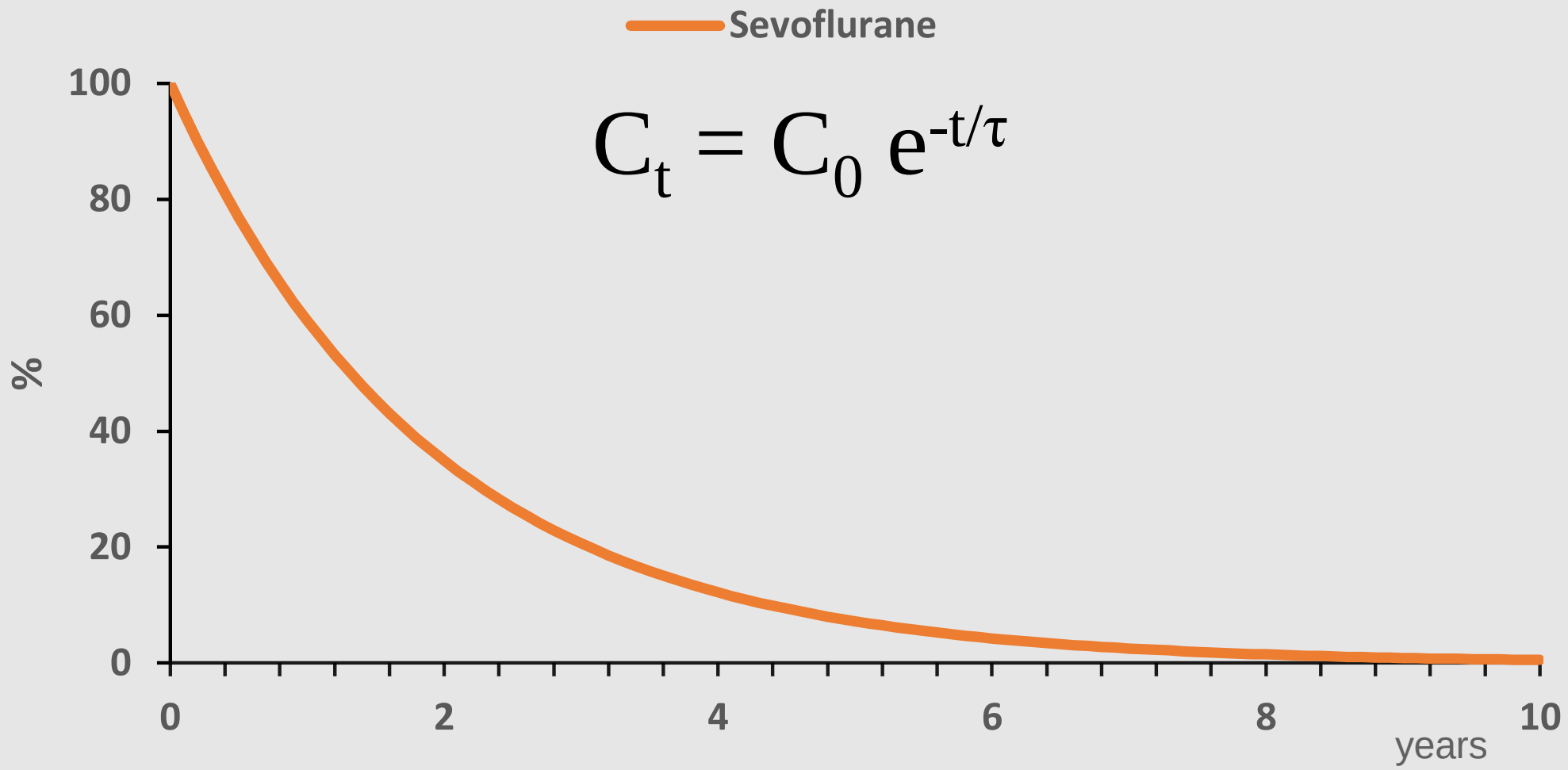
GWP
Atmospheric Natural Lifetime

Compound	Lifetime (y)
Sevoflurane	1.9
Isoflurane	3.5
Desflurane	14.1
N_2O	109

IPCC, 2021: Climate Change 2021: The Physical Science Basis.
https://www.ipcc.ch/report/ar6/wg1/#FullReport

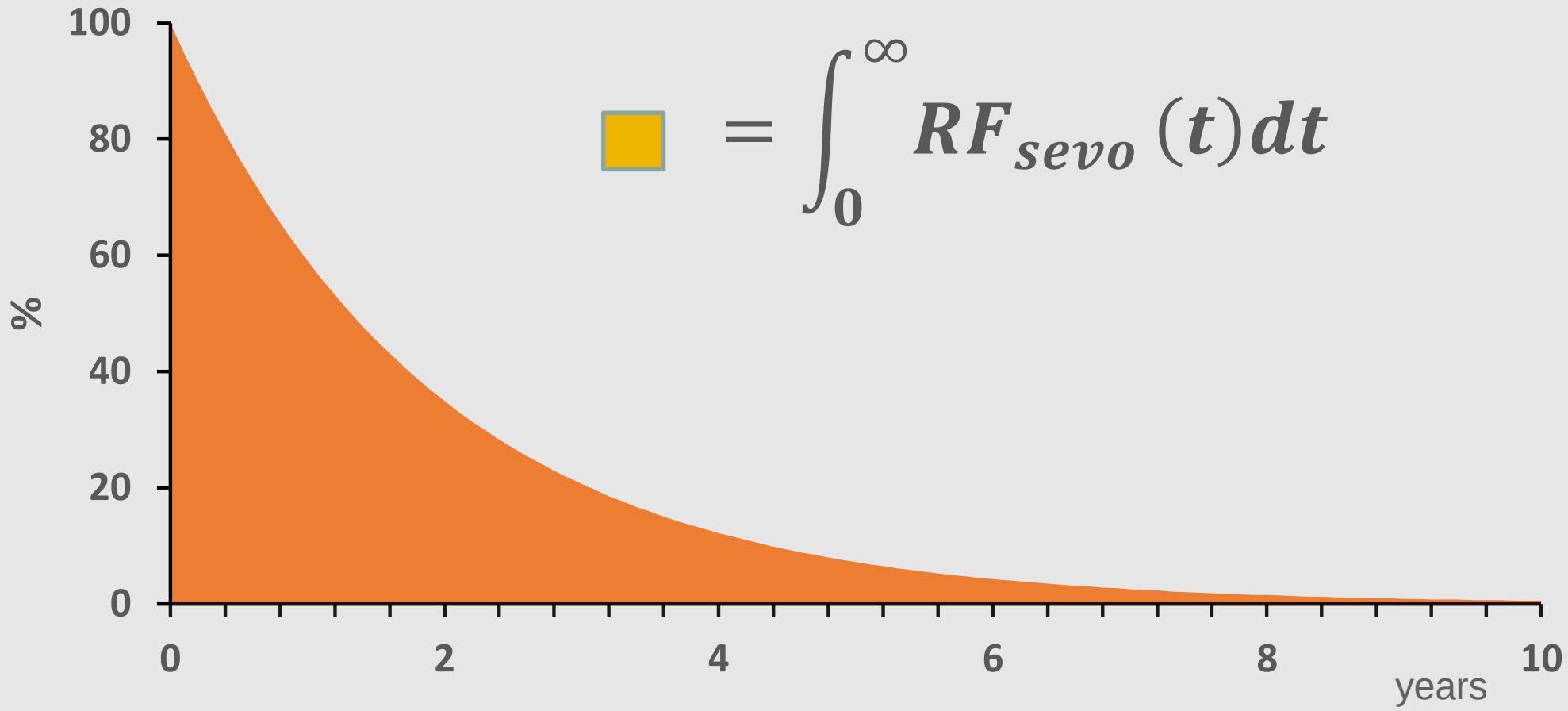
Natural decay of sevoflurane

$\tau_{sevo} \approx 1.9$ year



Total energy absorption

RE Sevoflurane : 0.31 W m^{-2} ppb^{-1}



$$= \int_0^\infty \boldsymbol{RF_{sevo}}\,(\boldsymbol{t})\boldsymbol{dt}$$

Anesthesia example:

Old anesthesia workstations:

Fresh Gas Flow : 8L/min
[Desflurane] in FGF : 6%

What is the CO_2e emission of desflurane during 1 week (40h) of anesthesia?

FGF = 8L/min (FGF= fresh gas flow)

FG concentration (desflurane) = 6%

1 mol desflurane @ 1 atm, 20°C = 24.06 Liter

Molecular weight (desflurane) = 168 g/mol

GWP_{20}(desflurane) = 7020 $g_{(CO_2)}$ / $g_{(desflurane)}$

FGF (desflurane) = 8L/min x 6% = 0.48 L/min

FGF (desflurane) = 0.48 L/min / 24.06 L/mol = 0.0199 mol/min

FGF (desflurane) = 0.0199 mol/min x 168 g/mol = 3.35 g/min

CO_2e (desflurane) = 3.35 g/min x 7020 = 23530 g CO_2e / min

= 23.53 kg CO_2e /min

1 week = 40 hours = 2400 min

➔ CO_2e(desflurane) = 23.53 kg CO_2e / min x 2400 min = 56,465 kg

= 56 ton CO_2/week

Emissions from Appendectomy

Surgery : All disposable instruments + packaging :

- carboard boxes :	431	g CO_2
- laparoscopic instruments :	4664	g CO_2
- 2 additional Trocars :	628	g CO_2
- 4 surgical Gowns	668	g CO_2
- 4 sets gloves	600	g CO_2
- Camera drape	39	g CO_2
- Cotton Gauze swabs	2566	g CO_2
- Barrier sheets	1200	g CO_2
	~ 11	kg CO_2

➔ **Emissions for production & incineration of al surgical disposables**

~ 11-15 kg CO_2 per procedure

Emissions from Appendectomy

Surgery : Production & incineration of all disposables & drapes

11-15 kg CO_2

Anesthesia: Production emissions & venting/incineration:

Syringes, needles, face mask, ETT,

laryngoscope blade, IV medication, … 2-3 kg CO_2

TIVA 60 minutes (propofol + disposables) : 0.3 kg CO_2

Emissions from Appendectomy

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11-15 kg CO_2

Anesthesia: Production emissions & venting/incineration:

Syringes, needles, face mask, ETT,
laryngoscope blade, IV medication, … **2-3 kg CO_2**

TIVA 60 minutes (propofol + disposables) : 0.3 kg CO_2

Volatile anesthetics 60 minutes : Sevoflurane 2% @ Et-control : 16 kg CO_2e

Emissions from Appendectomy

Surgery : Production & incineration of all disposables & drapes

11-15 kg CO_2

Anesthesia: Production emissions & venting/incineration:
Syringes, needles, face mask, ETT,
laryngoscope blade, IV medication, … **2-3 kg CO_2**

TIVA 60 minutes (propofol + disposables) :		**0.3**	**kg CO_2**
Volatile anesthetics 60 minutes :	**Sevoflurane 2% @ Et-control :**	**16**	**kg CO_2e**
	Sevoflurane 2% @ 2L FGF :	**28**	**kg CO_2e**
	Sevoflurane 2% @ 6L FGF :	**84**	**kg CO_2e**
N_2O 70/30 +	**Sevoflurane 2% @ 2L FGF :**	**70**	**kg CO_2e**
N_2O 70/30 +	**Sevoflurane 2% @ 6L FGF :**	**210**	**kg CO_2e**
	Desflurane 6% @ 2L FGF :	**388**	**kg CO_2e**
	Desflurane 6% @ 6L FGF :	**1165**	**kg CO_2e**

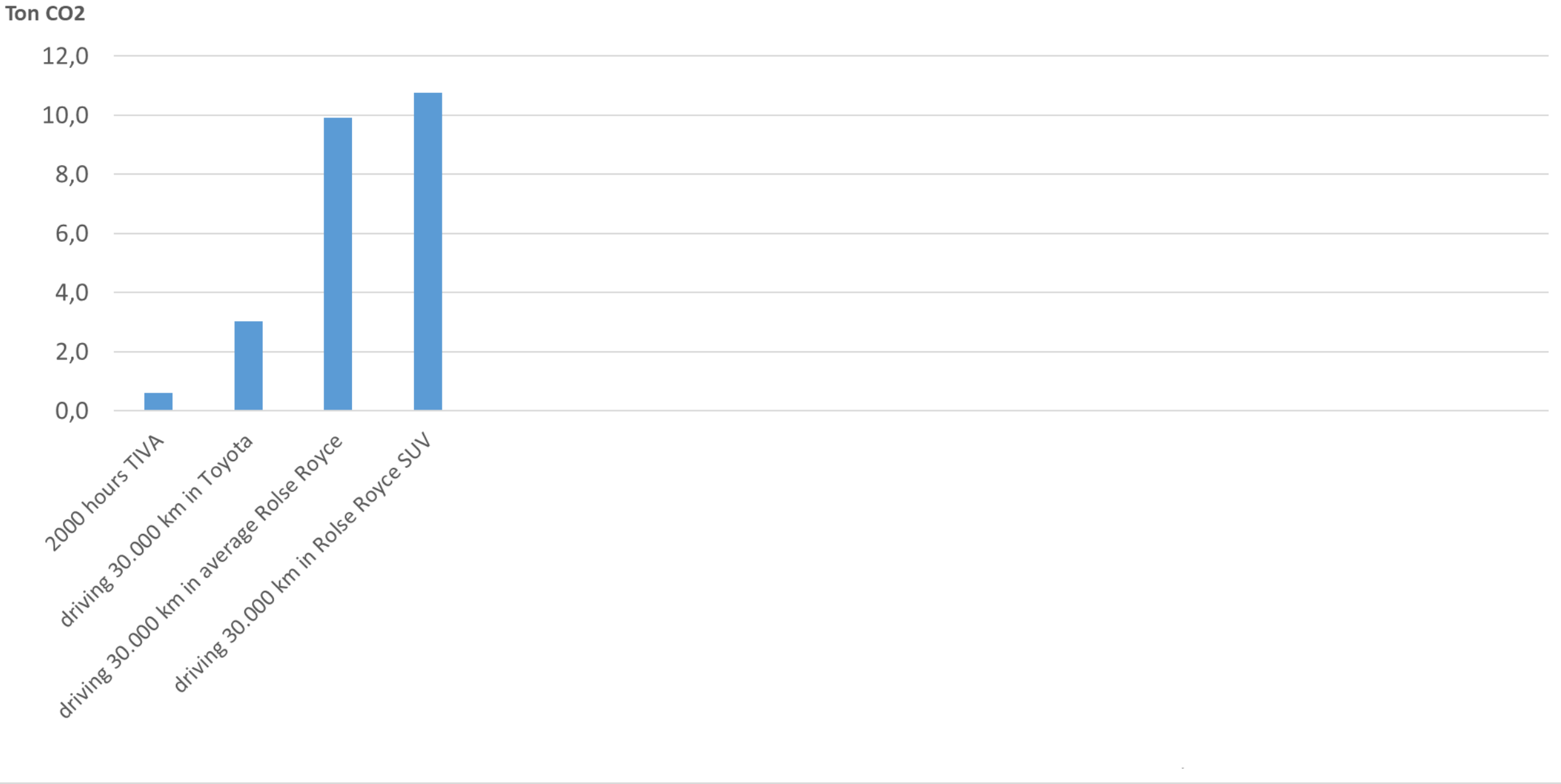
1 year (=2000 hours) of anesthesia

Impact of maintenance anesthesia on greenhouse gas emissions

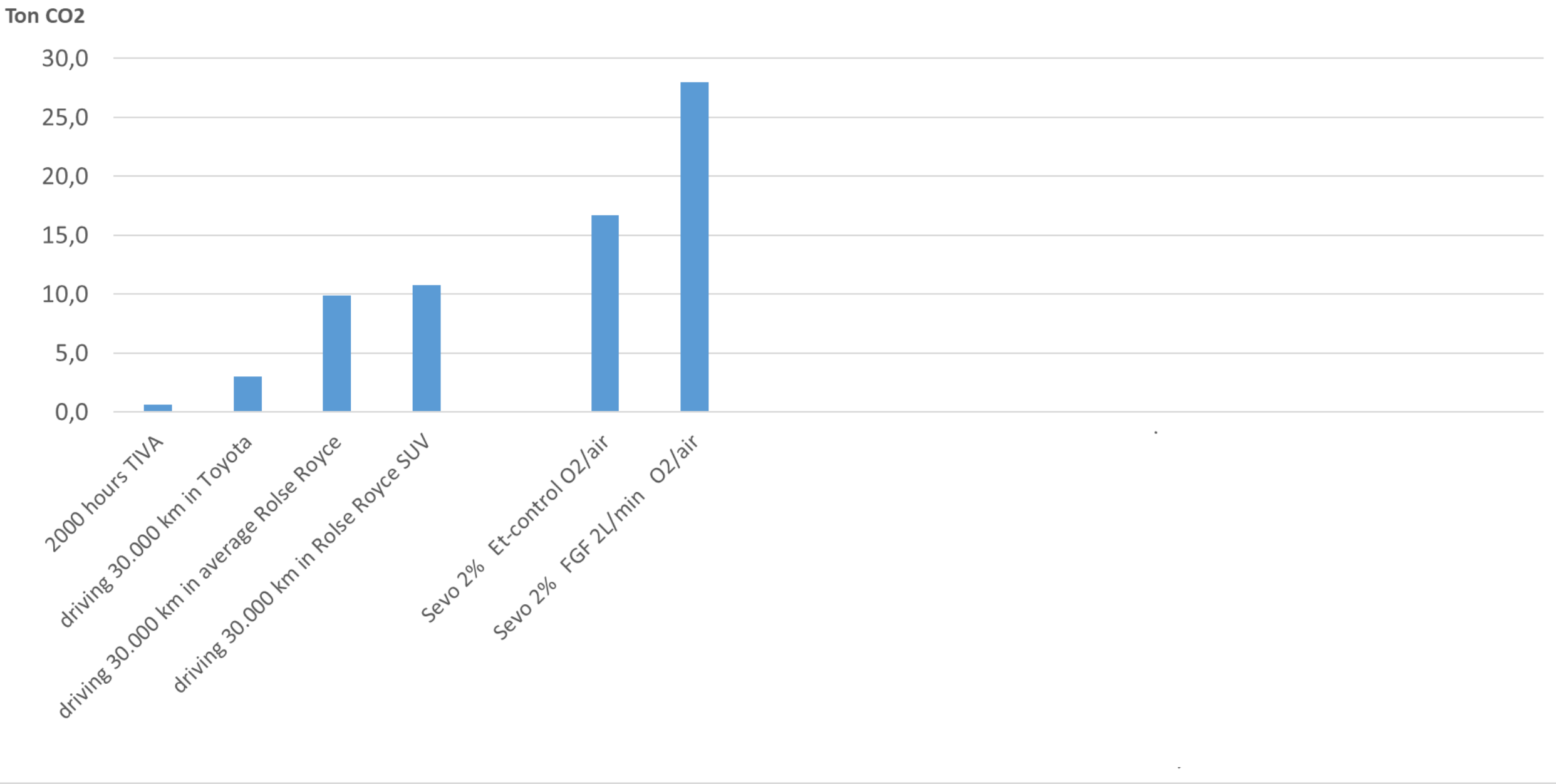
Tons CO2e emissions per year

Tons CO2e emissions per year

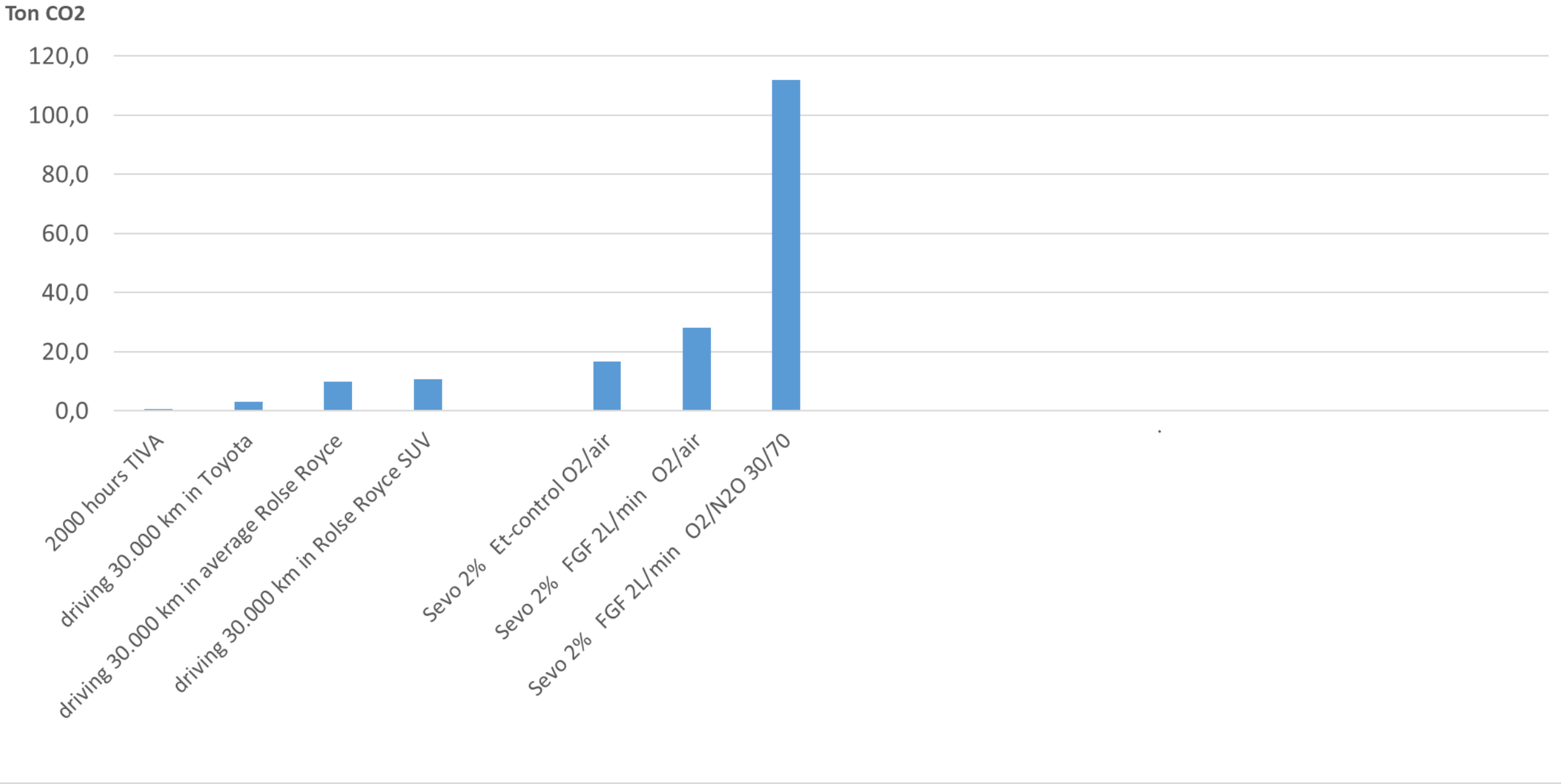
Tons CO2e emissions per year



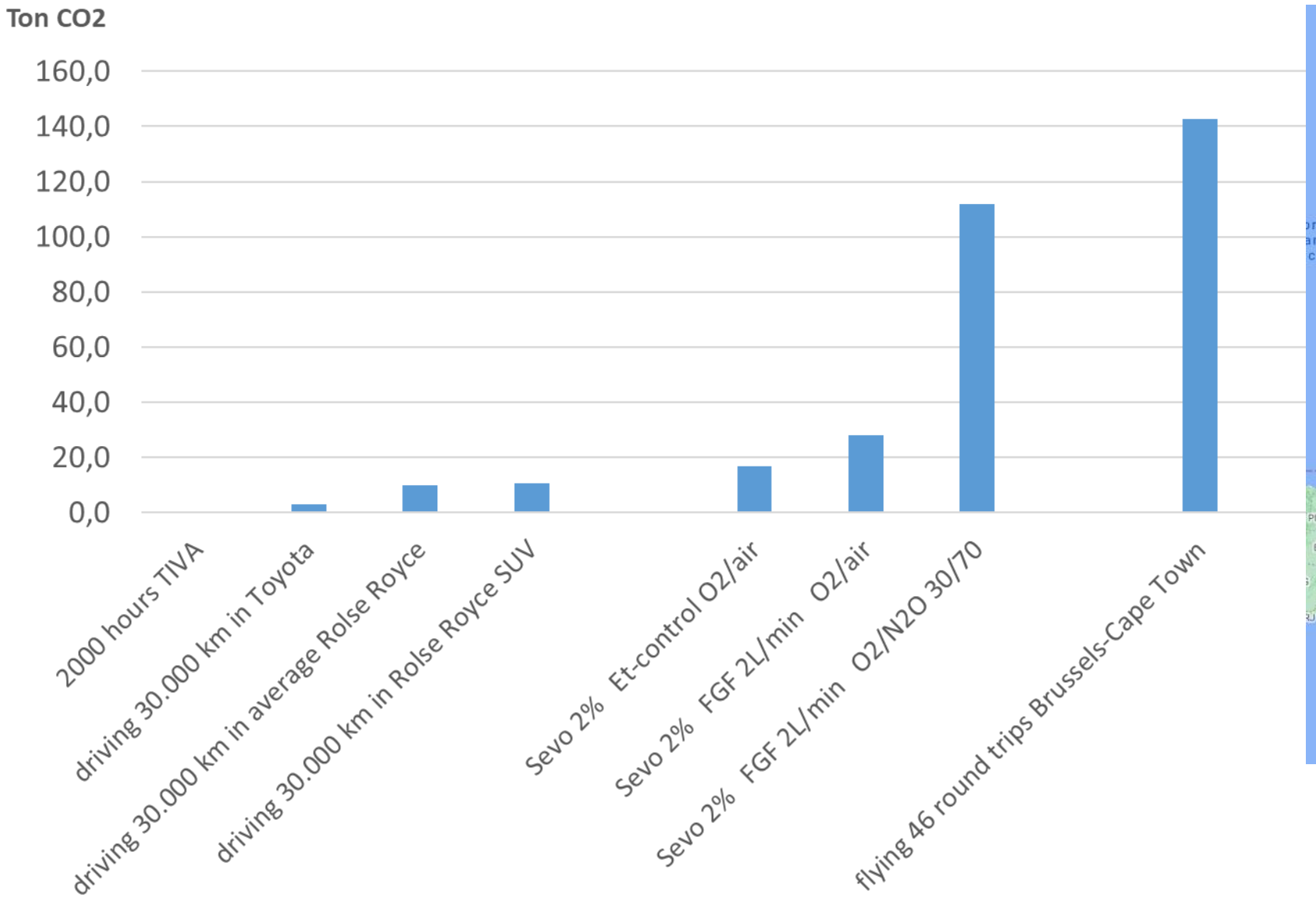
Tons CO2e emissions per year

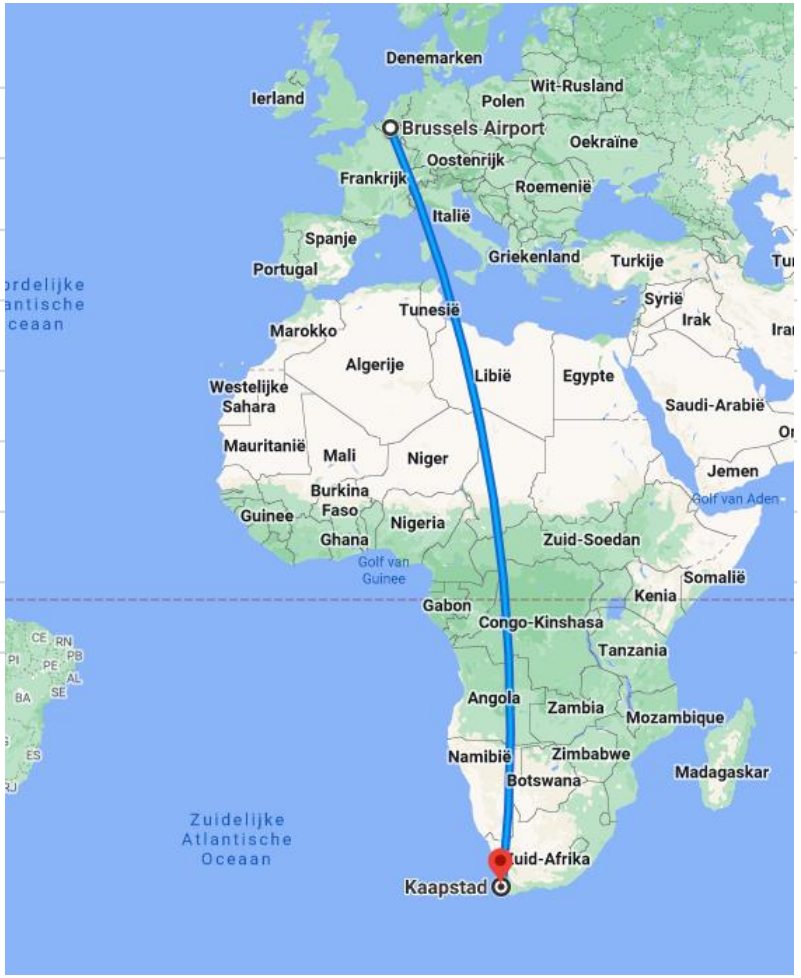


Tons CO2e emissions per year



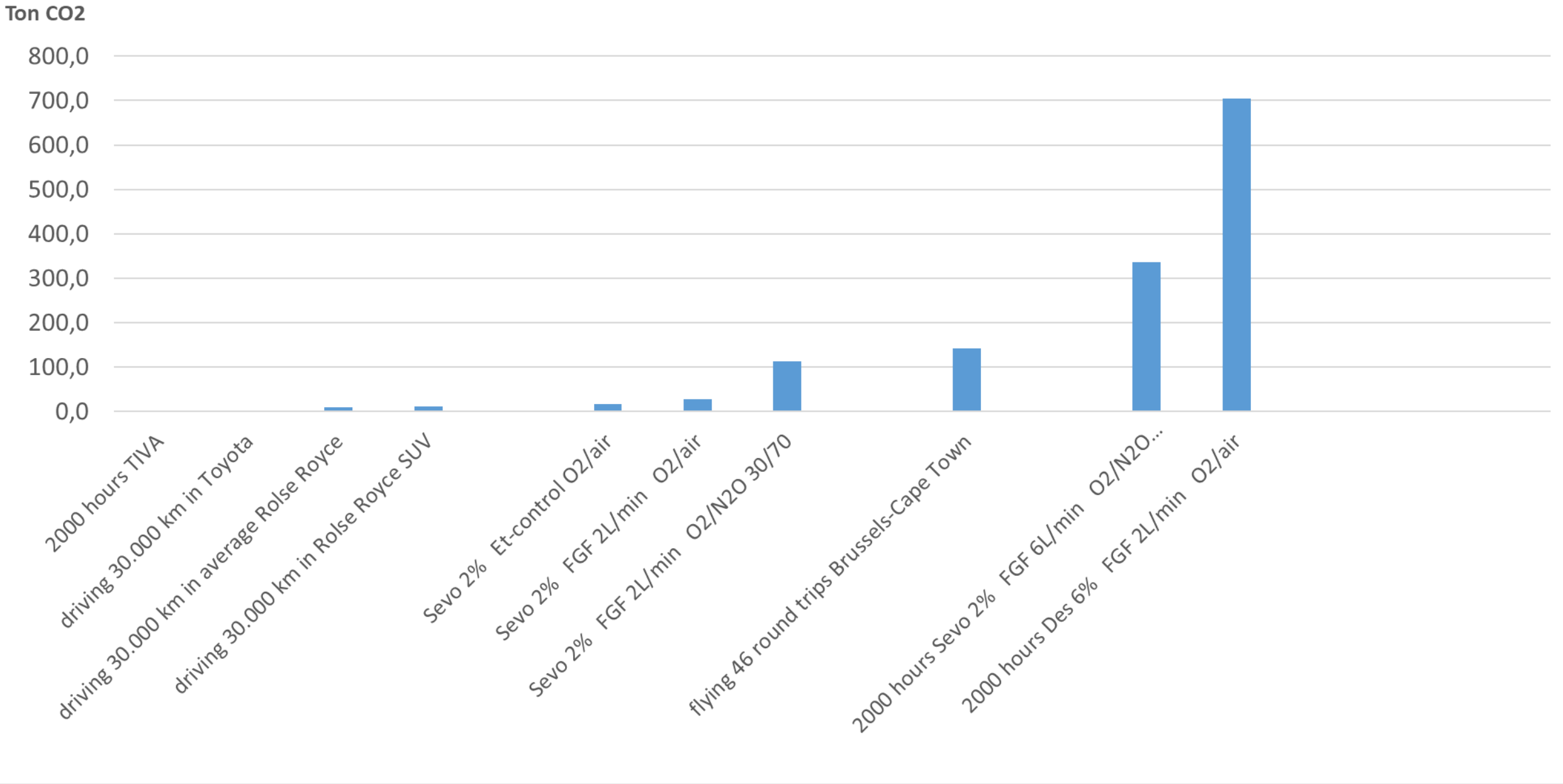
Tons CO2e emissions per year



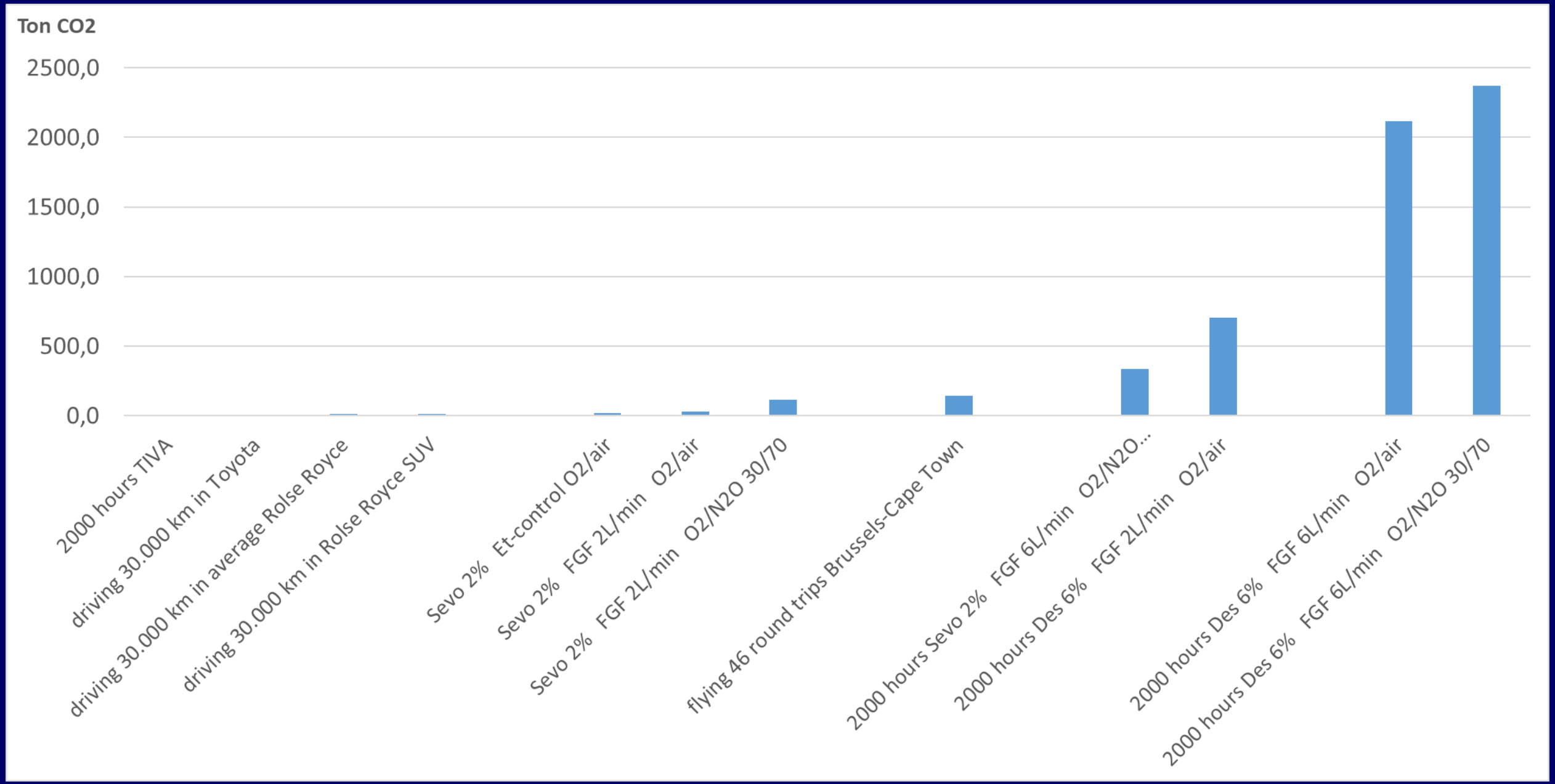


52 round trips Brussels – Cape Town
142,6 ton CO_2

Tons CO2e emissions per year



Tons CO2e emissions per year



Tons CO_2e emissions per year

Kim Kardashian

Private Jet : 100 flights of 6000 km
900.000 kg CO_2

Vegan Anesthetist
no car, solar energy

Desflurane anesthesia
2000 hours, 6L FGF
2.118.000 kg CO_2

1,72 ml des/min = 2,51 g des/min = 17,65 kg CO_2e/min = 2.118.000 kg CO_2e/year

Fugitive Emissions of N_2O

AZ Sint-Jan : - General leaks + cryogenic storage leaks

➔ massive fugitive emissions

- 5280 litre liquid N_2O / 365d

= 6441 kg N_2O

= 1.758.557 kg CO_2e

➔ Complete stop of N_2O via central distribution.

TIVA ?

No Volatile anesthetics
No need for low flow
➔ no need for sodalime
Higher consumption of Air, O_2

propofol + lot of plastic syringes, valves, extension lines

€?

?

?

Life Cycle Assessment Sevo-TIVA (Cradle to Grave)

TIVA ?

1 syringe + extension line: 41 gr plastic ~ 0.185 kg CO_2

Propofol 2%: 24 ml/h = 0.48 gr/h ~ 0.001 kg CO_2

5L FGF/min → O_2 + air ~ 0.112 kg CO_2

→ 0.298 kg CO_2 / hour

1 hour sevoflurane EtC ~ 5ml sevo ~ 5.3 kg CO_2

sodalime 30g plastic + 120g lime ~ 0.224 kg CO_2

0.4L FGF/min → O_2 ~ 0.018 kg CO_2

→ 5.542 kg CO_2 / hour

Cradle-to-gate greenhouse gas emissions for twenty anesthetic active pharmaceutical ingredients based on process scale-up and process design calculations. ACS Sustain Chem Eng 2019; 7: 6580–6591.

Comparison Sevo-TIVA

17862 procedures, average (SD) anesthesia time 92(73) minutes

Sevoflurane
Et-control

		unit price	amount	kg CO_2e	price
sevo AGC4 FiO_2 50%	20ml propofol ampules	0,55 €	46220	420	25.421 €
	20ml syringes	0,10 €	46220	2815	4.622 €
	blunt fill needles	0,03 €	46220	240	1.387 €
	sevoflurane ml	0,38 €	195984	418410	74.474 €
	sodalime canisters	14,87 €	1697	3801	25.221 €
	O_2 1000 litre	0,28 €	721	555	205 €
	air 1000 litre	0,02 €	104	10	2 €
	Σ			426251 kg	131.331 €

TIVA
Propofol 2%

		unit price	amount	kg CO_2e	price
propofol 8L FGF FiO_2 50%	50ml propofol 2% vials	1,74 €	17944	6343	31.222 €
	extension lines	0,50 €	17864	701	8.932 €
	3-way valves	0,15 €	17864	323	2.680 €
	back-check valves	0,70 €	3370	27	2.359 €
	blunt fill needles	0,03 €	17944	93	538 €
	50ml syringes	0,26 €	3370	465	876 €
	O_2 1000 litre	0,28 €	4845	3731	1.376 €
	air 1000 litre	0,02 €	8354	832	164 €
	Σ			12515 kg	48.147 €

Effect Propofol on Aquatic life

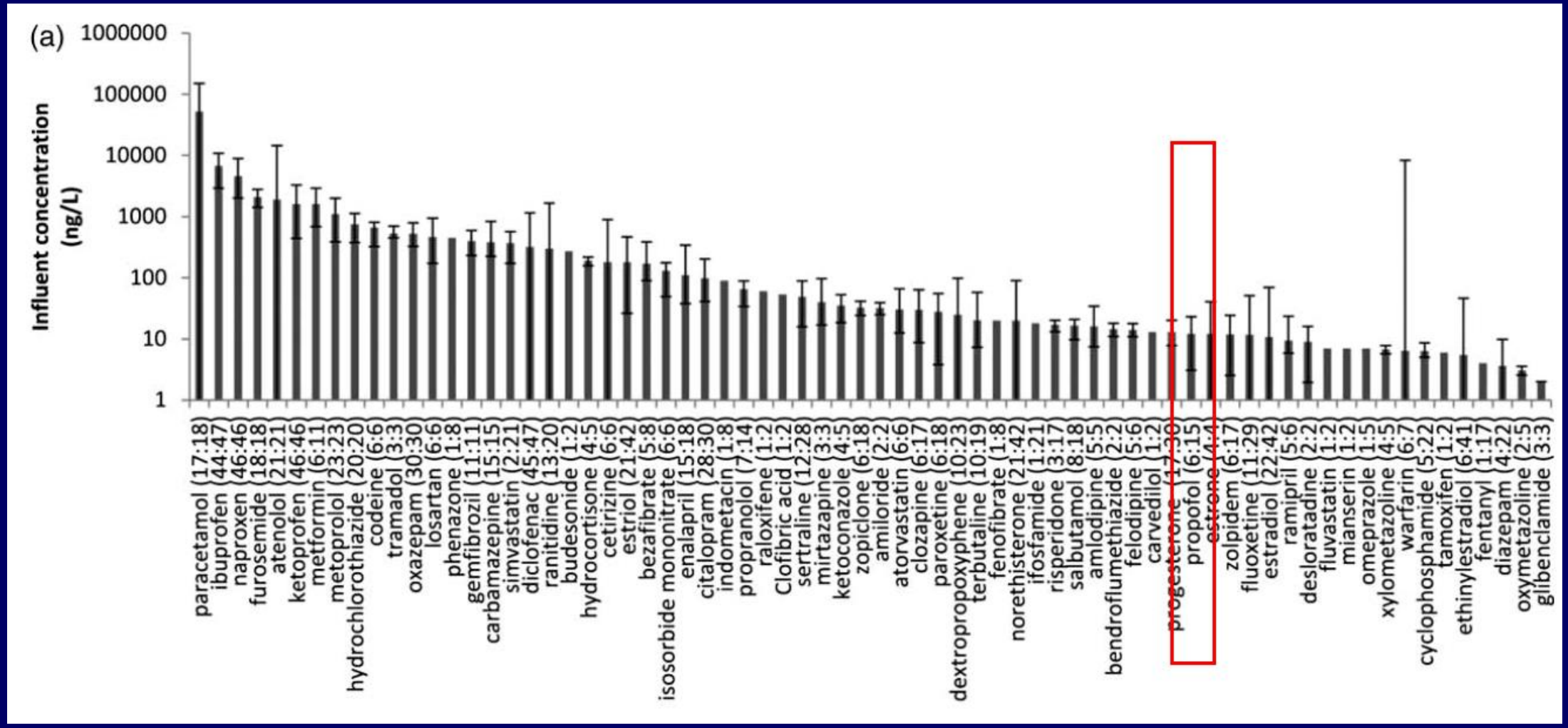
- Much debate, Very little to no scientific basis
- Harmless for plant life
- Very limited effect on fish (very low compared to other hospital pollutants)
- Comparable pharmacokinetics (renal clearance) as in humans ➔ no bioaccumulation in fish

Effect Propofol on Aquatic life

Propofol routinely used in veterinary anesthesia and aquaculture in:

- Nile Tilapia
- bamboo shark
- goldfish
- catfish
- koi carp
- rainbow trout
- Persian sturgeon
- benni

Occurrence of propofol in wastewater treatment plants from hospitals



Occurrence and reduction of pharmaceuticals in the waterphase at Swedish wastewater treatment plantsdoi: 10.2166/wst.2012.243

Long-term side effects of Anesthesia