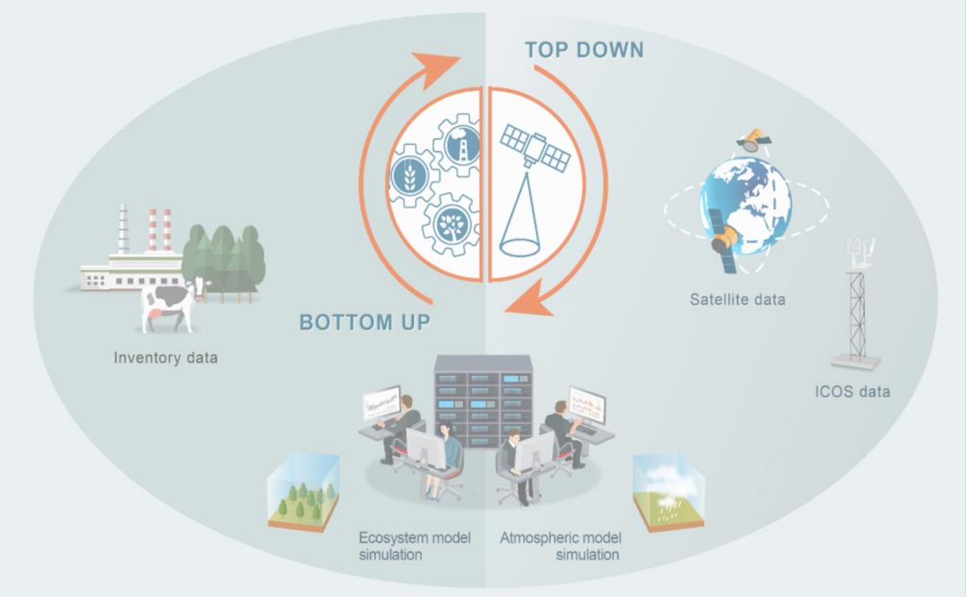
VERIFY General Assembly

May 9th-11th, 2022

Paris

WP7 (UEA) - Matt Jones and Adam Smith

with input from
Marco Carreira-Silva (Climate-KIC)



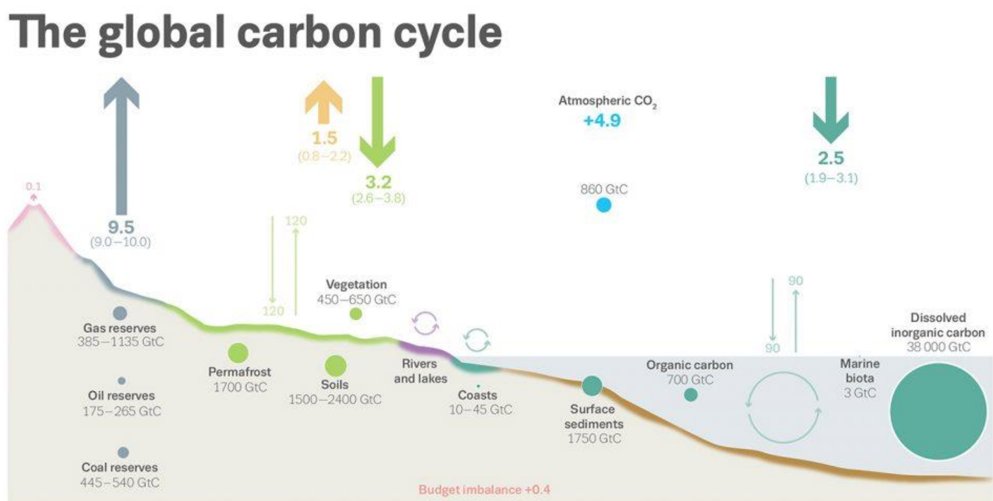
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776810

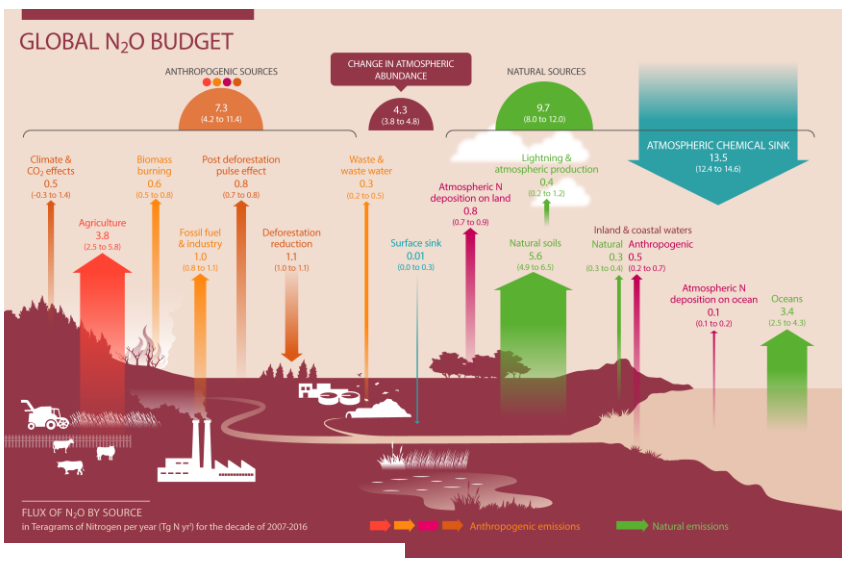
Content

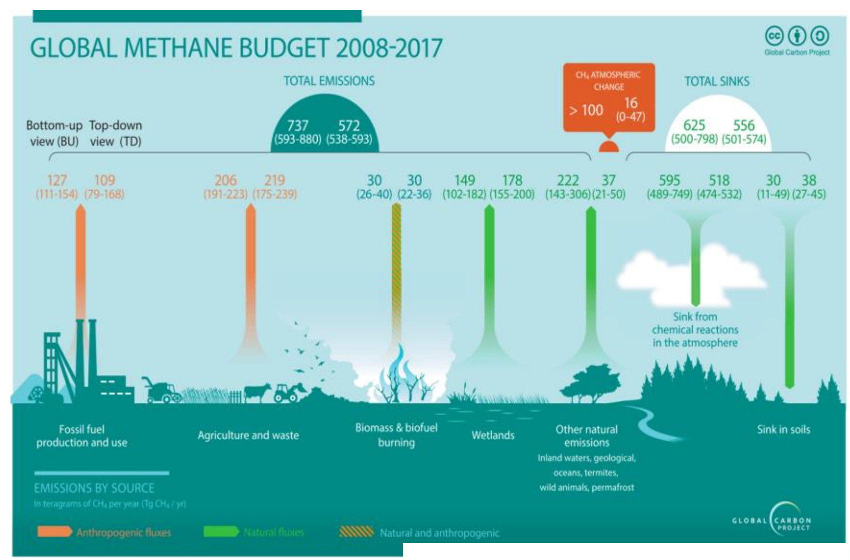
- Main achievements and scientific results
  - Global carbon project growing in presence and impact
  - Facilitating Top-Down Estimates in the Global Carbon Budget with GridFED
  - COVID-19 impact on emissions
  - European contributions to climate change
- Report on research needs for verification + “live survey”

GLOBAL CARBON PROJECT

Friedlingstein et al. (2021) Earth System Science Data







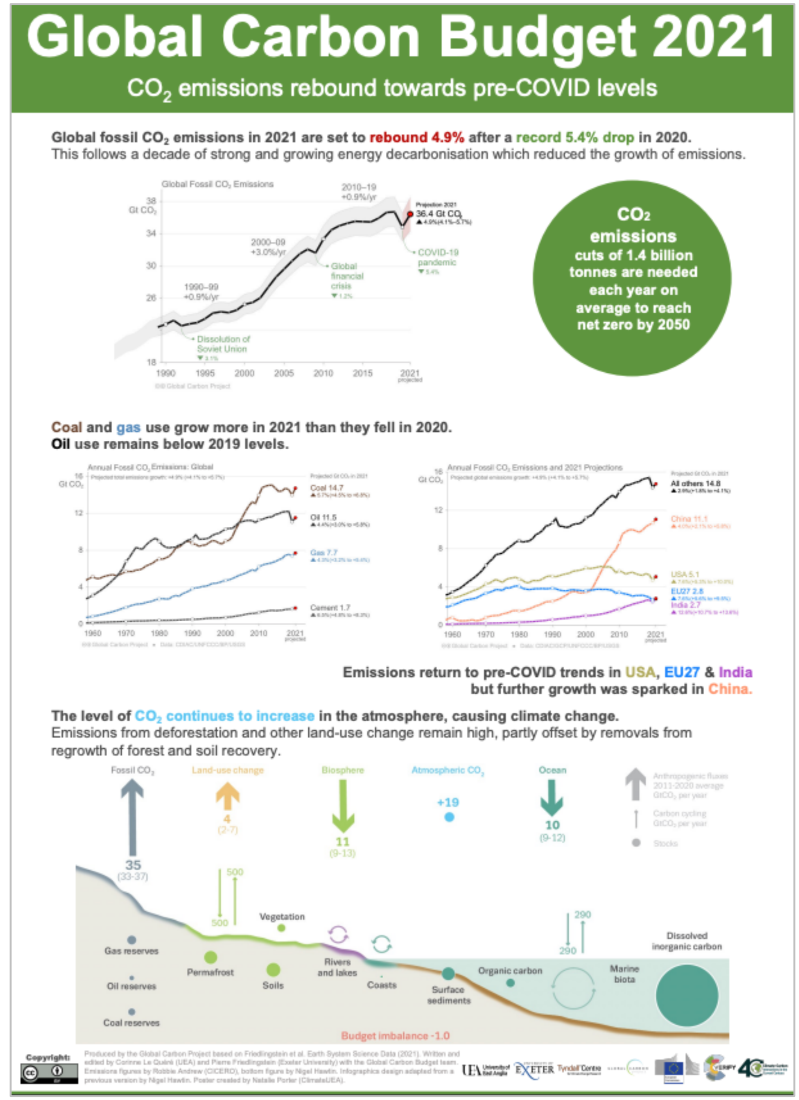
Tian et al. (2020), Nature

Saunois et al. (2020), ESSD

GCP use in High Impact Reports

Impact/Outreach Activities: Global Carbon Budget 2021

- **Commentary Articles**
  - Jackson et al., Environmental Research Letters
  - Article in The Conversation
- **Press pack**
  - Key messages
  - 7x press releases (UK, Norway, Australia, Germany, Japan, France, USA).
  - Suite of comms products (infographics, slide deck, animations for Twitter)
- **COP26**
  - Press briefing GCB Launch
  - Met Office Science Pavilion event
  - Public exhibition in the Green Zone
  - Packed schedule of media interviews (for TV / Radio / Print / Online)

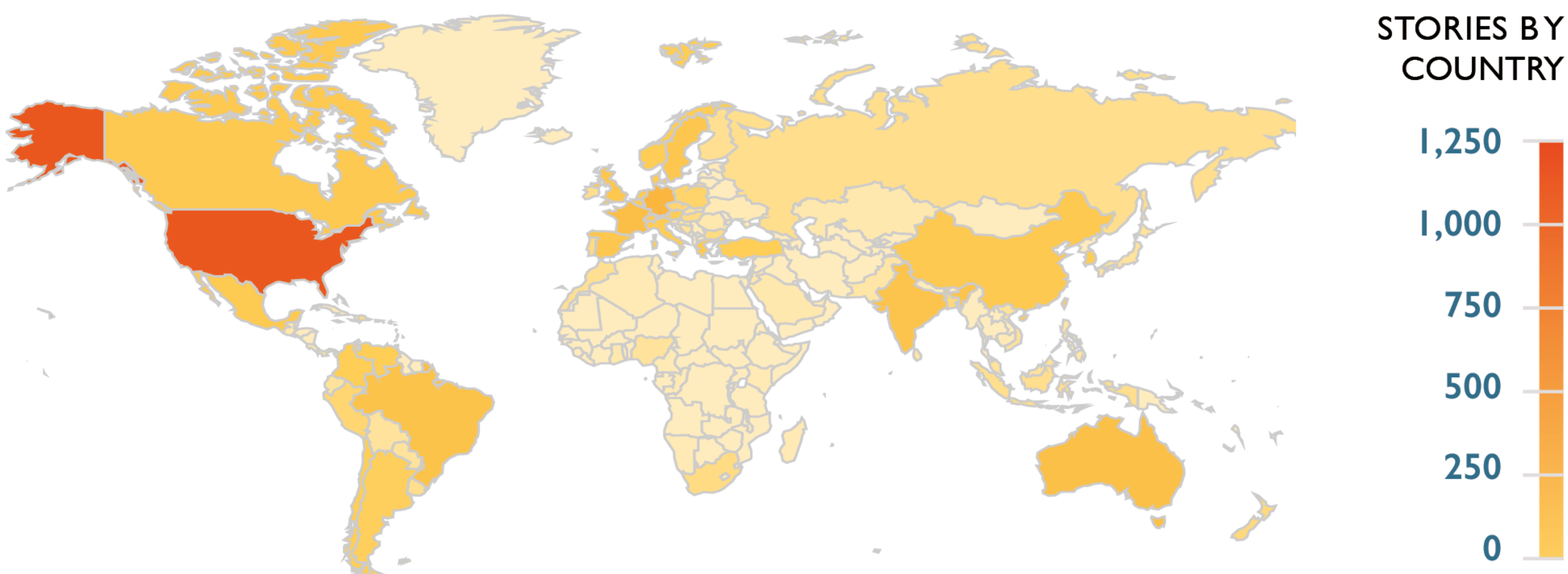


MEDIA COVERAGE: GLOBAL CARBON BUDGET

STORIES GENERATED
2,914

POTENTIAL REACH
2,519,459,840

ADVERTISING VALUE
USD 23,305,003



Meltwater Analysis
Courtesy of Pep Canadell

Science Impact: Global Carbon Budget

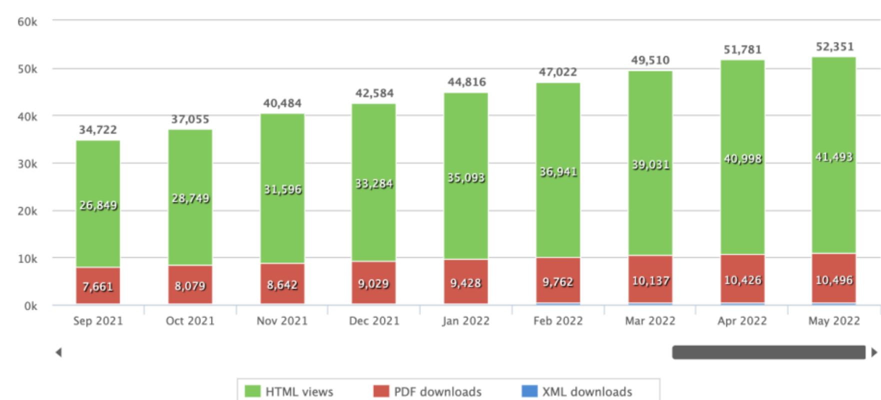
Earth Syst. Sci. Data, 14, 1917–2005, 2022
https://doi.org/10.5194/essd-14-1917-2022

Article | Assets | Peer review | Metrics | Related articles

Data description paper — 26 Apr 2022

Global Carbon Budget 2021

Cumulative views and downloads (calculated since 19 Aug 2019)



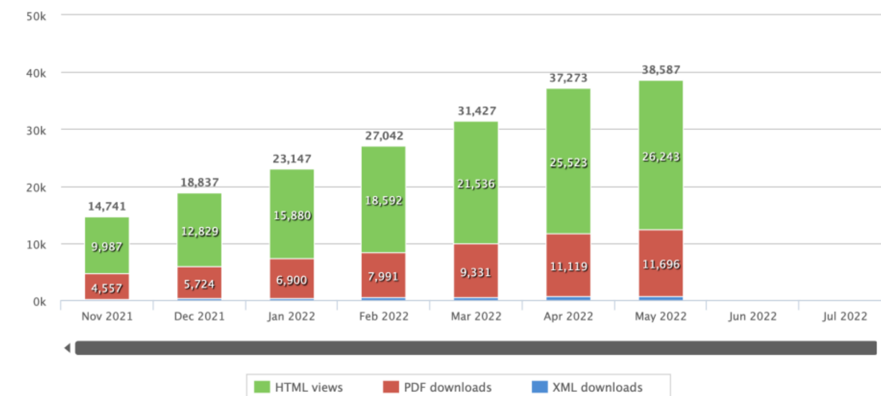
Earth Syst. Sci. Data, 12, 1561–1623, 2020
https://doi.org/10.5194/essd-12-1561-2020

Article | Assets | Peer review

Review article

The Global Methane Budget 2000–2017

Cumulative views and downloads (calculated since 04 Nov 2021)



nature — View all journals | Search

Explore content | About the journal | Publish with us | Sign up for al

nature > articles > article > article metrics

Article metrics | Last updated: Mon, 9 May 2022 11:08:53 Z

A comprehensive quantification of global nitrous oxide sources and sinks

Access & Citations

32k	193	234
Article Accesses	Web of Science	CrossRef

Citation counts are provided from Web o
The counts may vary by service, and are
of their data. Counts will update daily on

Meltwater Analysis
Courtesy of Pep Canadell

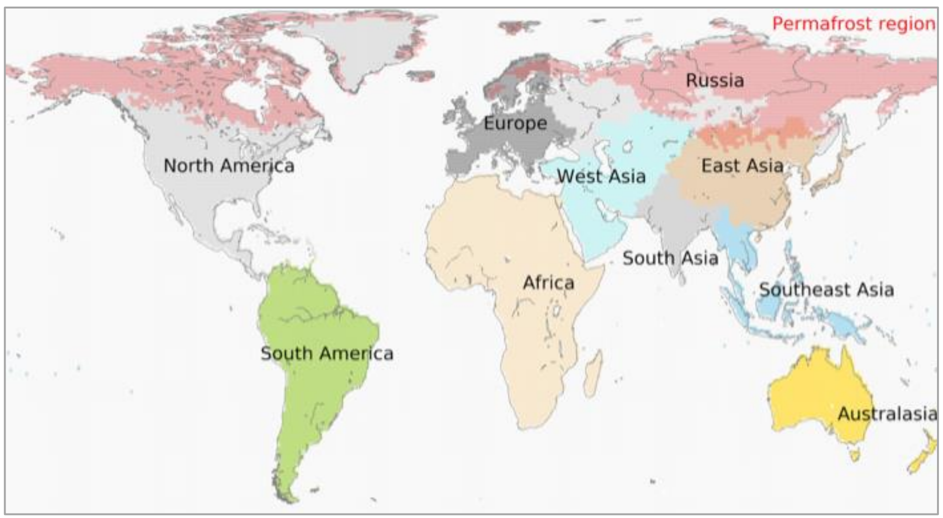
Education Impact

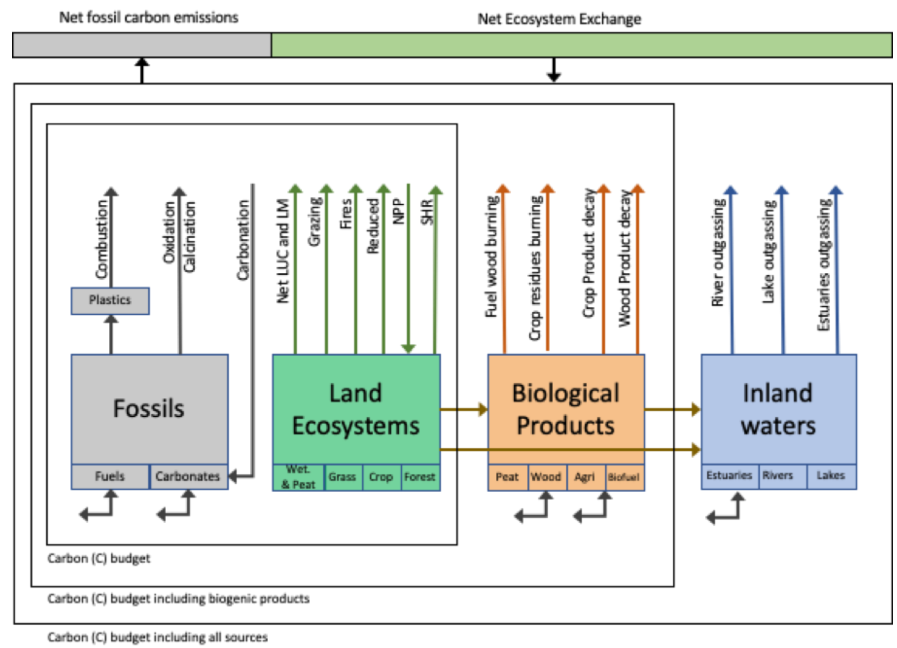
Robbie Andrew
@robbie_andrew

Every year the Global Carbon Project releases a Powerpoint slidedeck for anyone to use. As an experiment, I've converted some of the slides to an online format.
robbieandrew.github.io/GCB2021/slides

GlobalCarbonProject

REGIONAL CARBON CYCLE ASSESSMENT AND PROCESSES (RECCAP2)

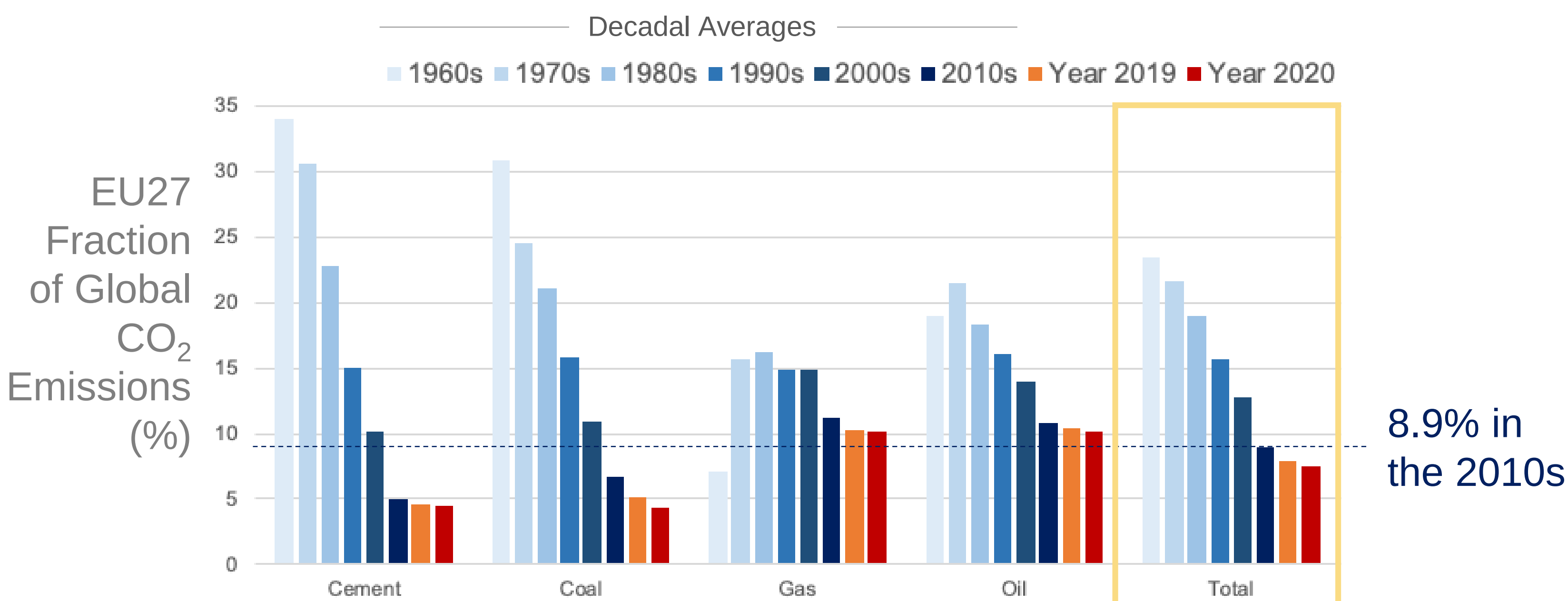




Ciais et al. (2022), GMD

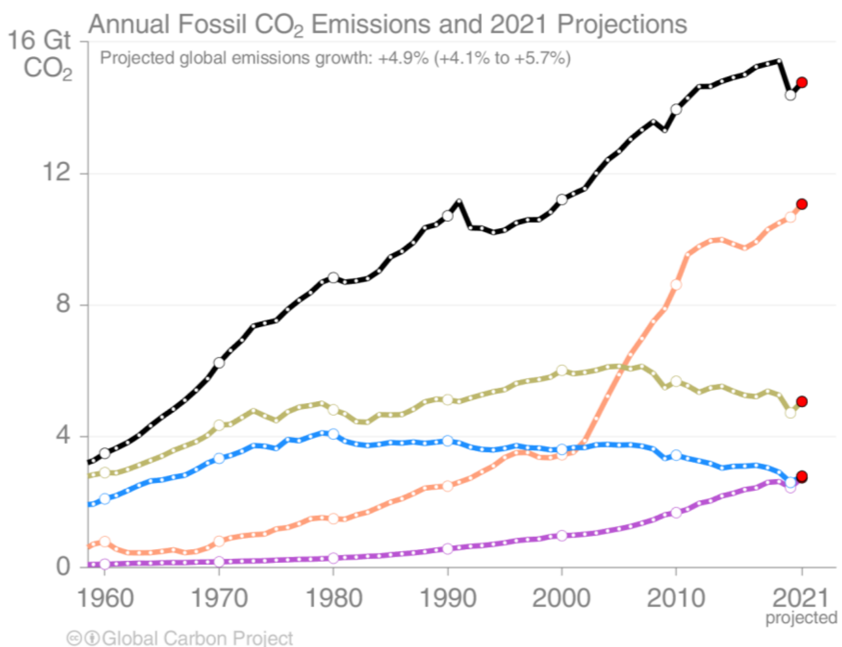
D7.1-D7.2-D7.3: Synthesis of the European contribution to Anthropogenic Emissions

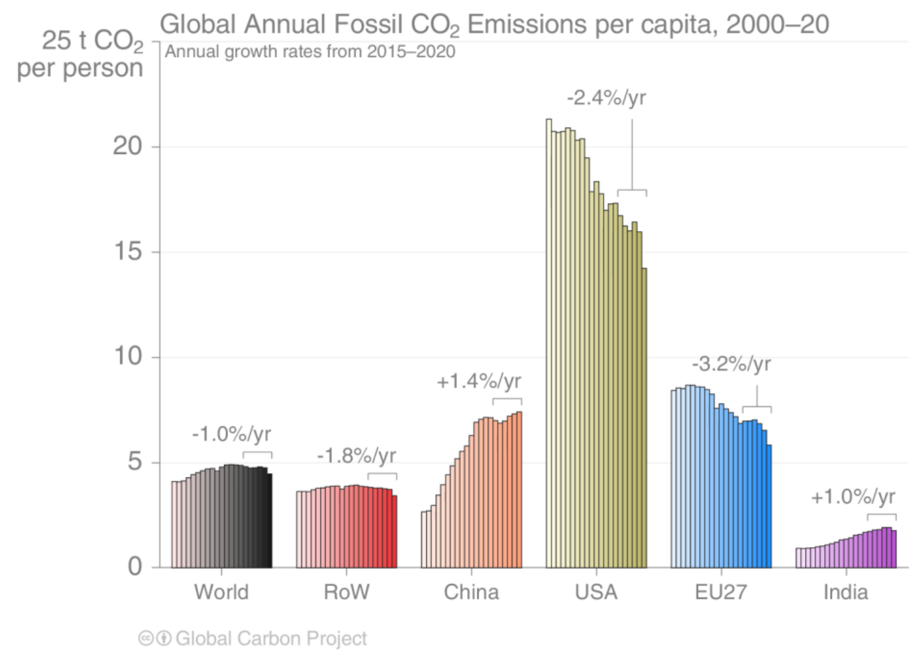
- EU27 contributions to annual fossil CO_2 emissions (does not include land use fluxes or unmanaged sinks/sources on European territory).



Data from Friedlingstein et al., 2021

D7.1-D7.2-D7.3: Synthesis of the European contribution to Anthropogenic Emissions





Data from Friedlingstein et al., 2021, Credit GCP/R. Andrew

D7.1-D7.2-D7.3: Synthesis of the European contribution to Anthropogenic Emissions

- European contributions to CH_4 emissions over the latest decade of available data (bottom-up and top-down)

Methane (2008-2017)

		Bottom-up	**Top-down**
Total	Global	**333 ± 10** Tg CH_4 $year^{-1}$	**345 ± 80** Tg CH_4 $year^{-1}$
	Europe*	7%	7%
Agriculture & Waste	Global	**198 ± 20** Tg CH_4 $year^{-1}$	**201 ± 80** Tg CH_4 $year^{-1}$
	Europe*	9%	8%
Fossil Fuels	Global	**118 ± 15** Tg CH_4 $year^{-1}$	**112 ± 40** Tg CH_4 $year^{-1}$
	Europe*	4%	6%

*EU27 plus UK, Norway, Switzerland, Bosnia and Herzegovina, Montenegro, Albania, and North Macedonia

Data from Saunois et al., 2020

D7.1-D7.2-D7.3: SYNTHESIS OF THE EUROPEAN CONTRIBUTION TO ANTHROPOGENIC EMISSIONS

- European contributions to N_2O emissions over the latest decade of available data (bottom-up)

Nitrous Oxide (2007-2016)

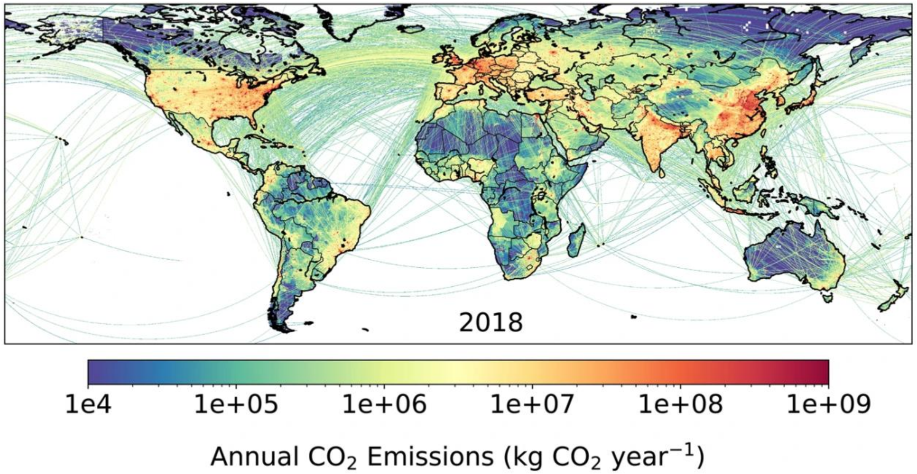
Total	Global	**7.3** ± **4** Tg N_2O year^{-1}
	Europe	13%
Agriculture (mostly soil emissions and manure)	Global	**3.8** ± **2** Tg N_2O year^{-1}
	Europe	14%
Other direct emissions (Fossil fuels and industry + waste and waste water + Biomass burning)	Global	**1.9** ± **0.3** Tg N_2O year^{-1}
	Europe	11%

*EU27 plus UK, Norway, Switzerland, Bosnia and Herzegovina, Montenegro, Albania, and North Macedonia

Data from Tian et al., 2020

FACILITATING TOP-DOWN ESTIMATES IN THE GCB & RECCAP2 WITH GRIDFED

- **Goal:** enhance the "compatibility" of flux estimates from top-down and bottom-up approaches.
- **Approach:** create a gridded emissions product in which fossil emissions fluxes match those reported in the bottom-up carbon budget.
- **Result:**
  - Sum of the land and ocean sinks matches the bottom-up budget.
  - Closer agreement between the top-down and bottom-up estimates of land & ocean sinks.
  - Closer agreement between inversion models on the split of the land and ocean sinks.



Jones et al., 2021, Scientific Data

Impact of the Covid-19 Pandemic on CO_2 Emissions

Methods tied to policy ’confinement levels’

nature climate change
ARTICLES
https://doi.org/10.1038/s41558-020-0797-x
Check for updates

Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement

Corinne Le Quéré[1,2]✉, Robert B. Jackson[3,4,5], Matthew W. Jones[1,2], Adam J. P. Smith[1,2], Sam Abernethy[3,6], Robbie M. Andrew[7], Anthony J. De-Gol[1,2], David R. Willis[1,2], Yuli Shan[8], Josep G. Canadell[9], Pierre Friedlingstein[10,11], Felix Creutzig[12,13] and Glen P. Peters[7]

nature climate change
ARTICLES
https://doi.org/10.1038/s41558-020-0883-0
Check for updates

Current and future global climate impacts resulting from COVID-19

Piers M. Forster[1]✉, Harriet I. Forster[2], Mat J. Evans[3,4], Matthew J. Gidden[5,6], Chris D. Jones[7], Christoph A. Keller[8,9], Robin D. Lamboll[10], Corinne Le Quéré[11,12], Joeri Rogelj[6,10], Deborah Rosen[1], Carl-Friedrich Schleussner[5,13], Thomas B. Richardson[1], Christopher J. Smith[1,6] and Steven T. Turnock[1,7]

nature climate change
BRIEF COMMUNICATION
https://doi.org/10.1038/s41558-021-01001-0
Check for updates

Fossil CO_2 emissions in the post-COVID-19 era

Corinne Le Quéré[1,2]✉, Glen P. Peters[3], Pierre Friedlingstein[4,5], Robbie M. Andrew[3], Josep G. Canadell[6], Steven J. Davis[7], Robert B. Jackson[8,9,10] and Matthew W. Jones[1,2]

Methods directly utilising activity data

nature COMMUNICATIONS
https://doi.org/10.1038/s41467-020-18922-7 OPEN

Near-real-time monitoring of global CO_2 emissions reveals the effects of the COVID-19 pandemic

Zhu Liu et al.#

SCIENTIFIC DATA

Carbon Monitor, a near-real-time daily dataset of global CO_2 emission from fossil fuel and cement production

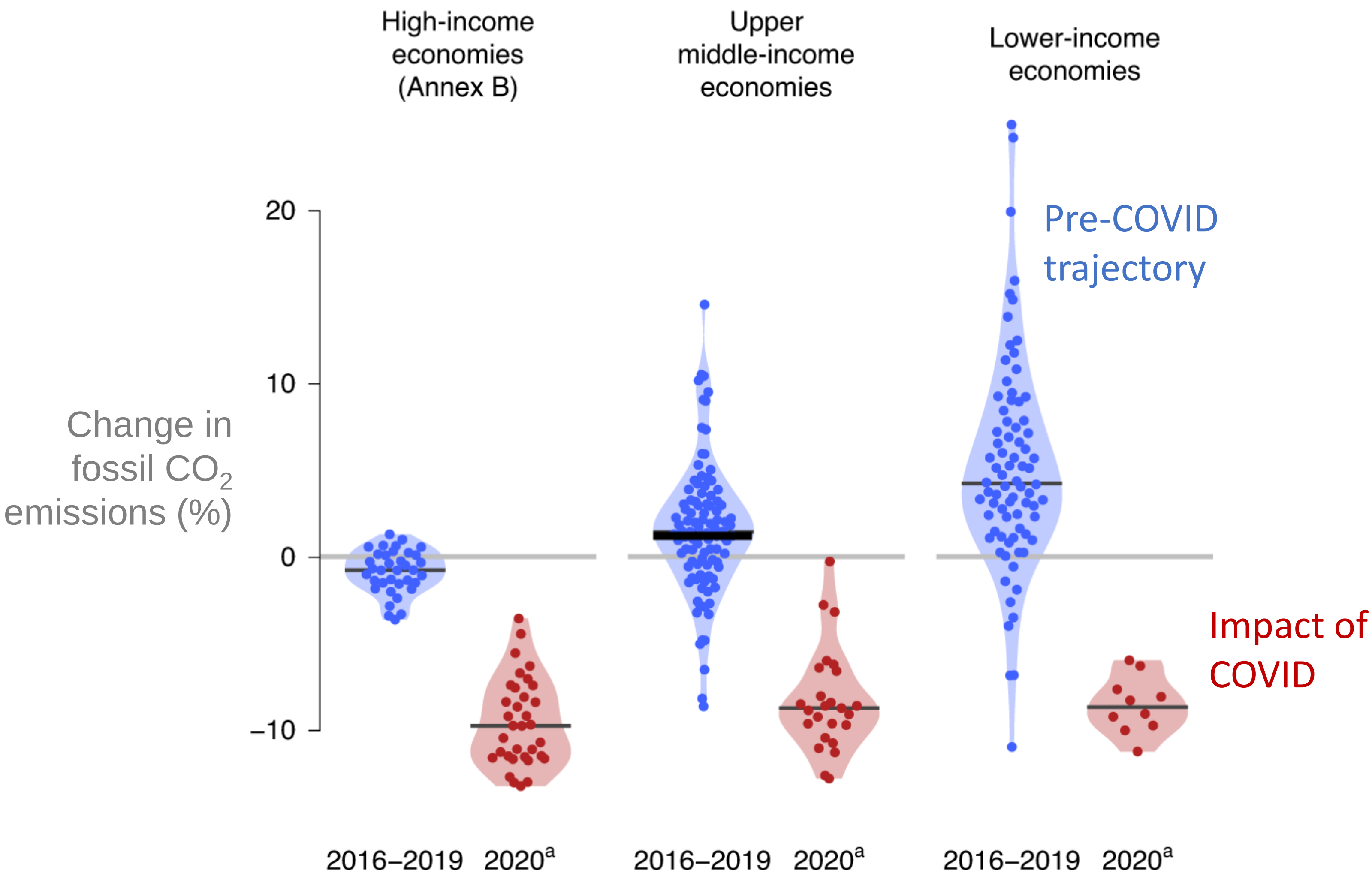
Zhu Liu[1,13]✉, Philippe Ciais[2,13]✉, Zhu Deng[1,13], Steven J. Davis[3]✉, Bo Zheng[2], Yilong Wang[4], Duo Cui[1], Biqing Zhu[1], Xinyu Dou[1], Piyu Ke[1], Taochun Sun[1], Rui Guo[1], Haiwang Zhong[5], Olivier Boucher[6], François-Marie Bréon[2], Chenxi Lu[1], Runtao Guo[7], Jinjun Xue[8,9,10], Eulalie Boucher[11], Katsumasa Tanaka[2,12] & Frédéric Chevallier[2]

The Innovation
Volume 3, Issue 1, 25 January 2022, 100182
CellPress

Near-real-time global gridded daily CO_2 emissions

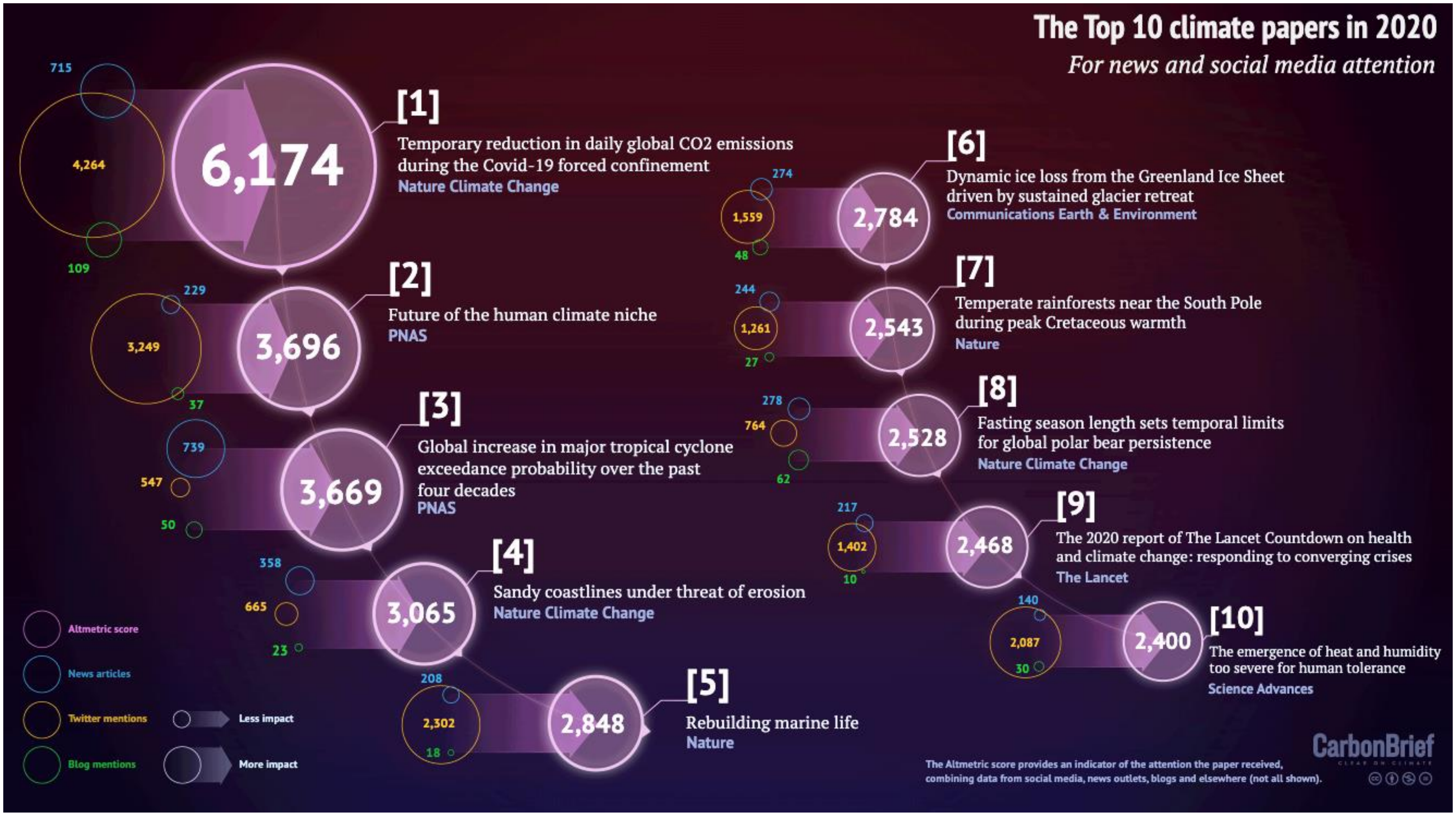
Xinyu Dou [1], Yilong Wang [2], Philippe Ciais [3], Frédéric Chevallier [3], Steven J. Davis [4], Monica Crippa [5], Greet Janssens-Maenhout [5], Diego Guizzardi [5], Efisio Solazzo [5], Feifan Yan [6], Da Huo [1], Bo Zheng [7], Biqing Zhu [1], Duo Cui [1], Piyu Ke [1], Taochun Sun [1], Hengqi Wang [1], Qiang Zhang [1] … Zhu Liu [1] ✉

Impact of the Covid-19 Pandemic on the CO_2 Emissions



Le Quéré et al., 2021, Nature Climate Change

IMPACT OF RESEARCH ON COVID-19 PANDEMIC



D7.4-D7.5: EU contribution to European Cumulative Emissions and to Warming

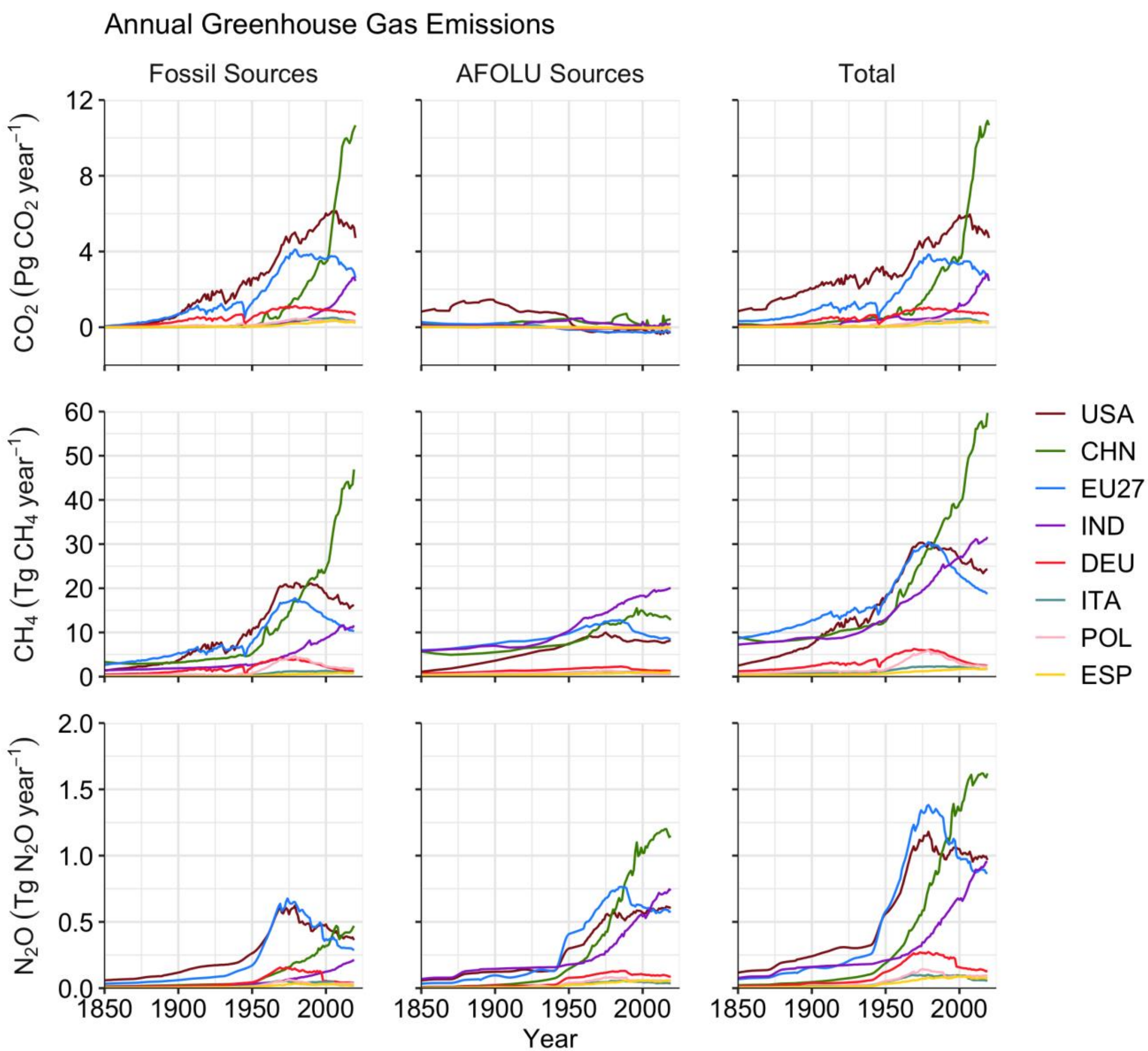
- **Goal:** provide a new dataset of national contributions to global warming due to historical emissions of CO_2, CH_4 and N_2O

- **Method:**
  - Collated global emissions time series for each country (fossil and AFOLU separated)
  - Expressed emissions of all gases in terms of their equivalence to cumulative CO_2 emissions using GWP*
  - Estimated the warming effect of historical emissions (1870-2019) using the transient climate response to cumulative CO_2 emissions (TCRE)

D7.4-D7.5: EU contribution to Global Cumulative Emissions and to Warming

Global Carbon Budget

PRIMAP-hist



Jones et al., in prep.

D7.4-D7.5: EU contribution to Global Cumulative Emissions and to Warming

- **CO_2 equivalence of historical N_2O emissions**
  - based on GWP-100 value for N_2O from IPCC AR6.
  - 1 kg of N_2O has same warming effect over a 100 year time horizon as 273 kg of CO_2

- **CO_2 equivalence of historical CH_4 emissions**
  - based on the GWP* approach, with GWP-100 values CH_4 from IPCC AR6

npj | Climate and Atmospheric Science www.nature.com/npjclimatsci

ARTICLE OPEN

A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation

Myles R. Allen[1,2], Keith P. Shine[3], Jan S. Fuglestvedt[4], Richard J. Millar[1], Michelle Cain[1,5], David J. Frame[6] and Adrian H. Macey[7]

npj | Climate and Atmospheric Science www.nature.com/npjclin

ARTICLE OPEN

Improved calculation of warming-equivalent emissions for short-lived climate pollutants

Michelle Cain[1,2], John Lynch[3], Myles R. Allen[1,3], Jan S. Fuglestvedt[4], David J. Frame[5] and Adrian H Macey[6,7]

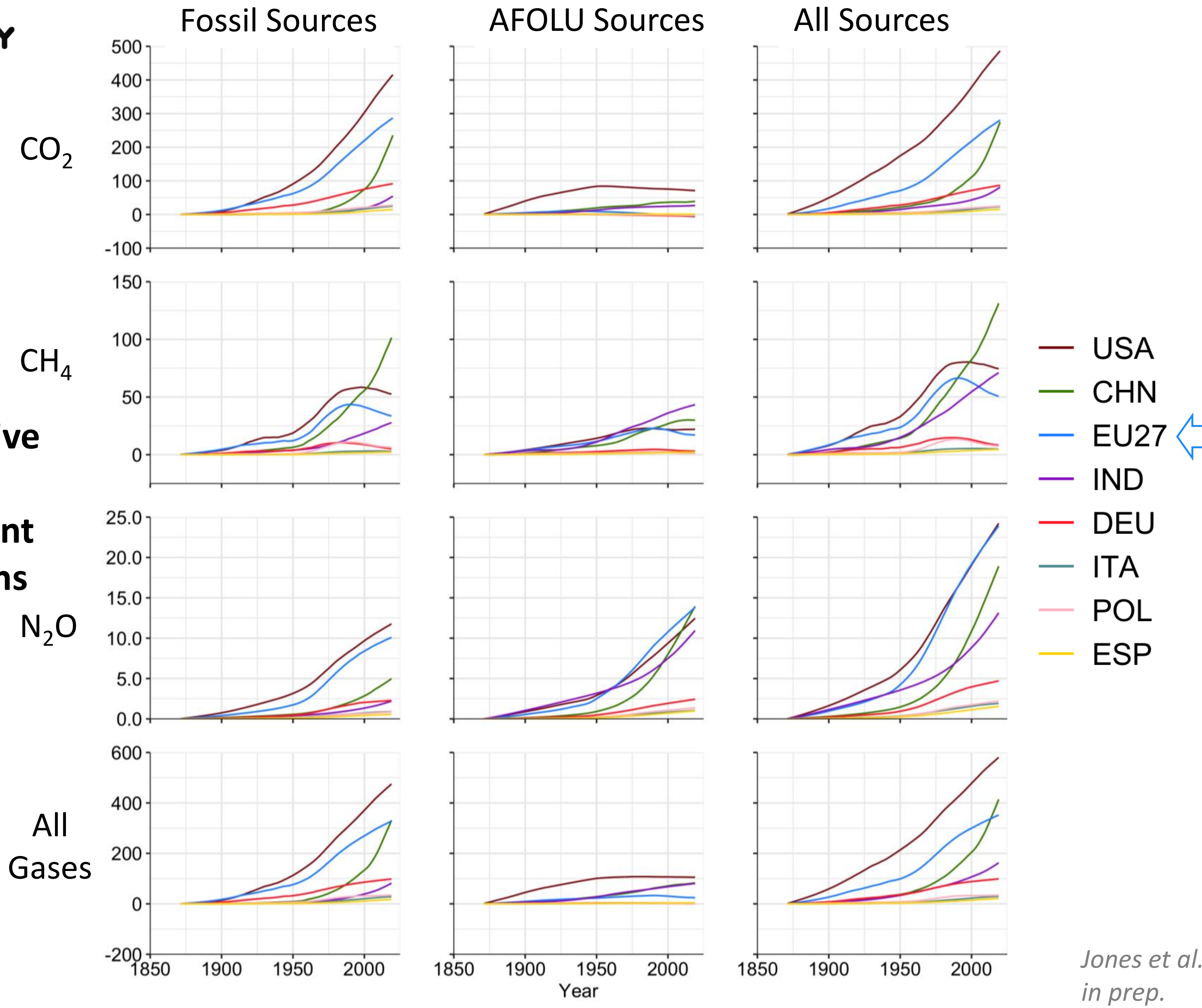
npj | Climate and Atmospheric Science www.nature.co

MATTERS ARISING OPEN

Further improvement of warming-equivalent emissions calculation

M. A. Smith[1,2], M. Cain[1,3] and M. R. Allen[1,2]

Cumulative CO2-equivalent Emissions



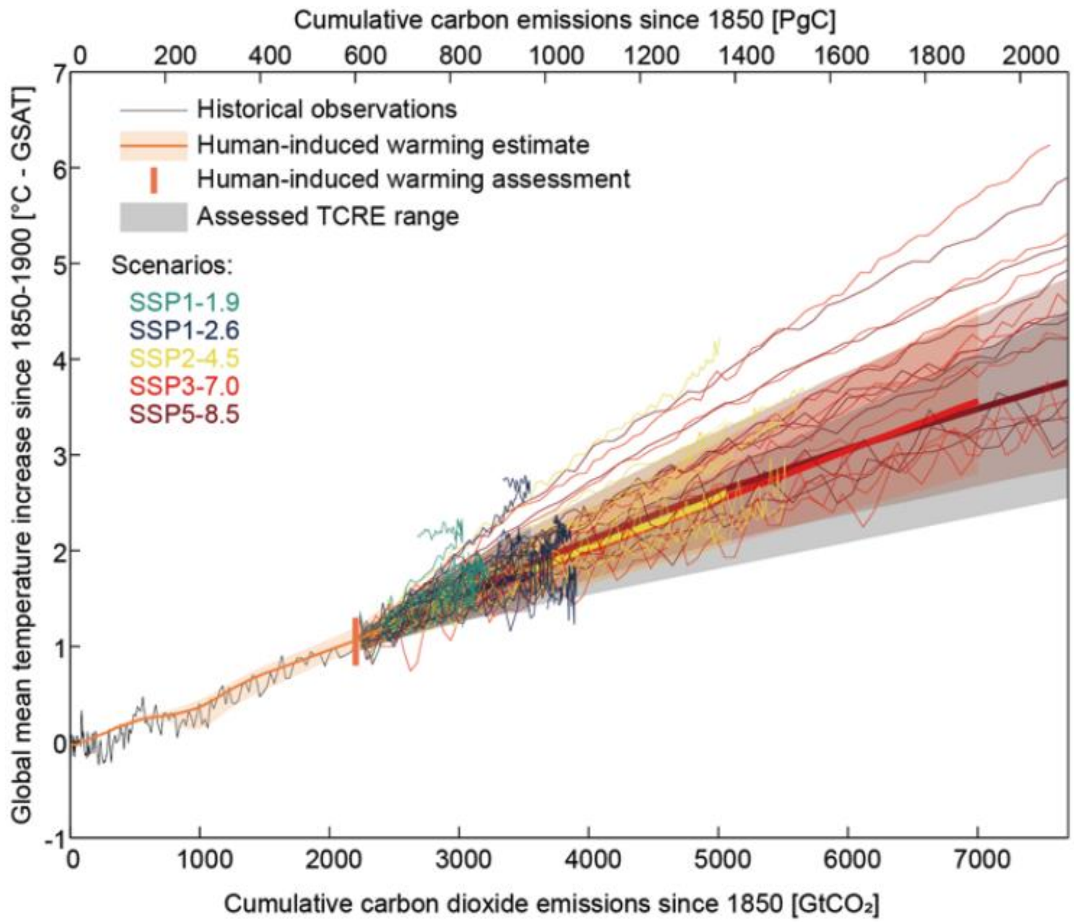
Jones et al., in prep.

D7.4-D7.5: EU CONTRIBUTION TO GLOBAL CUMULATIVE EMISSIONS AND TO WARMING

- Transient Climate Response to Cumulative Emissions of CO_2 (TCRE)

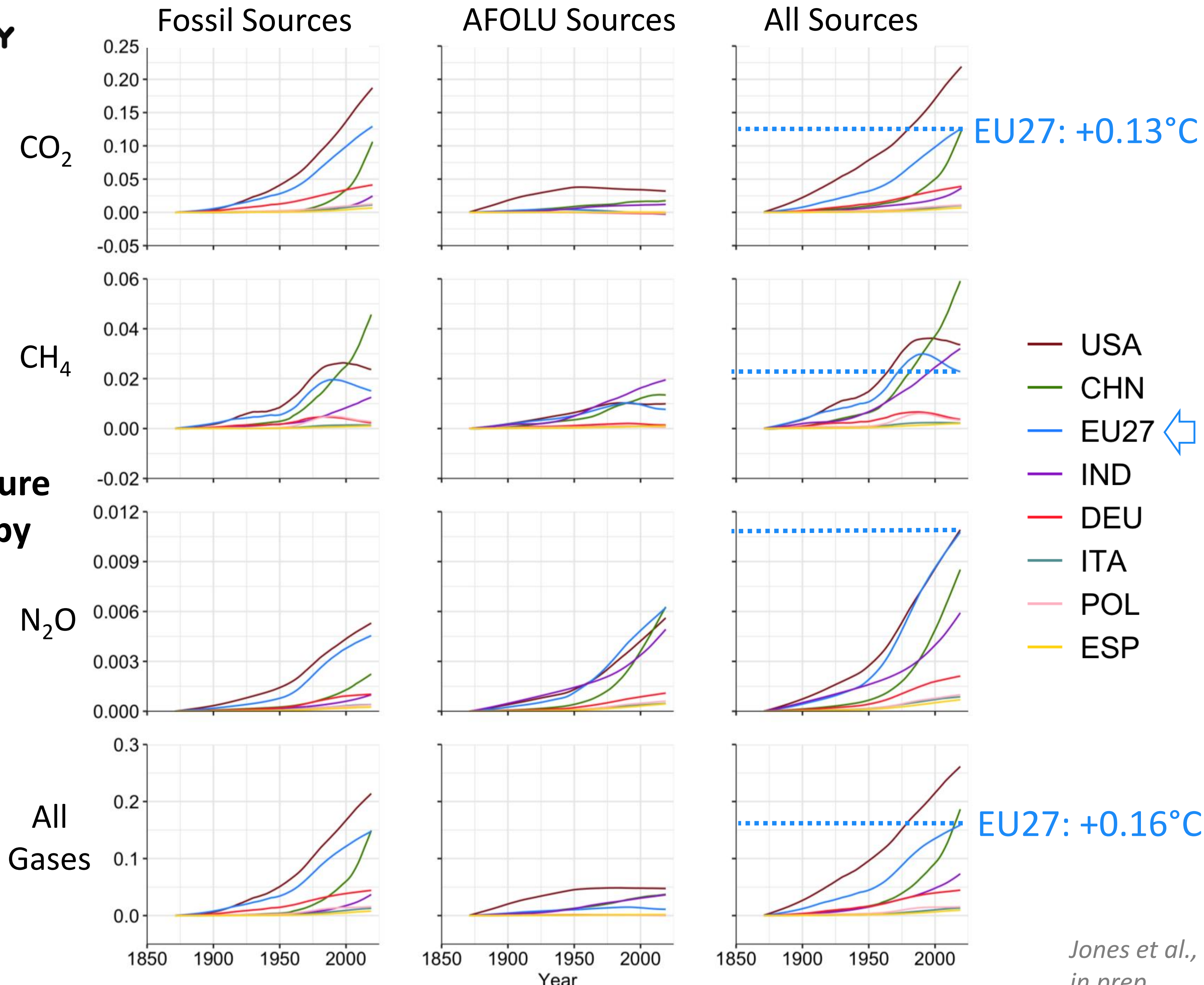
  1.65 °C warming per 1,000 Pg C emitted

- Derived from the simulated responses of global mean surface temperature to cumulative CO_2 emission in climate models.



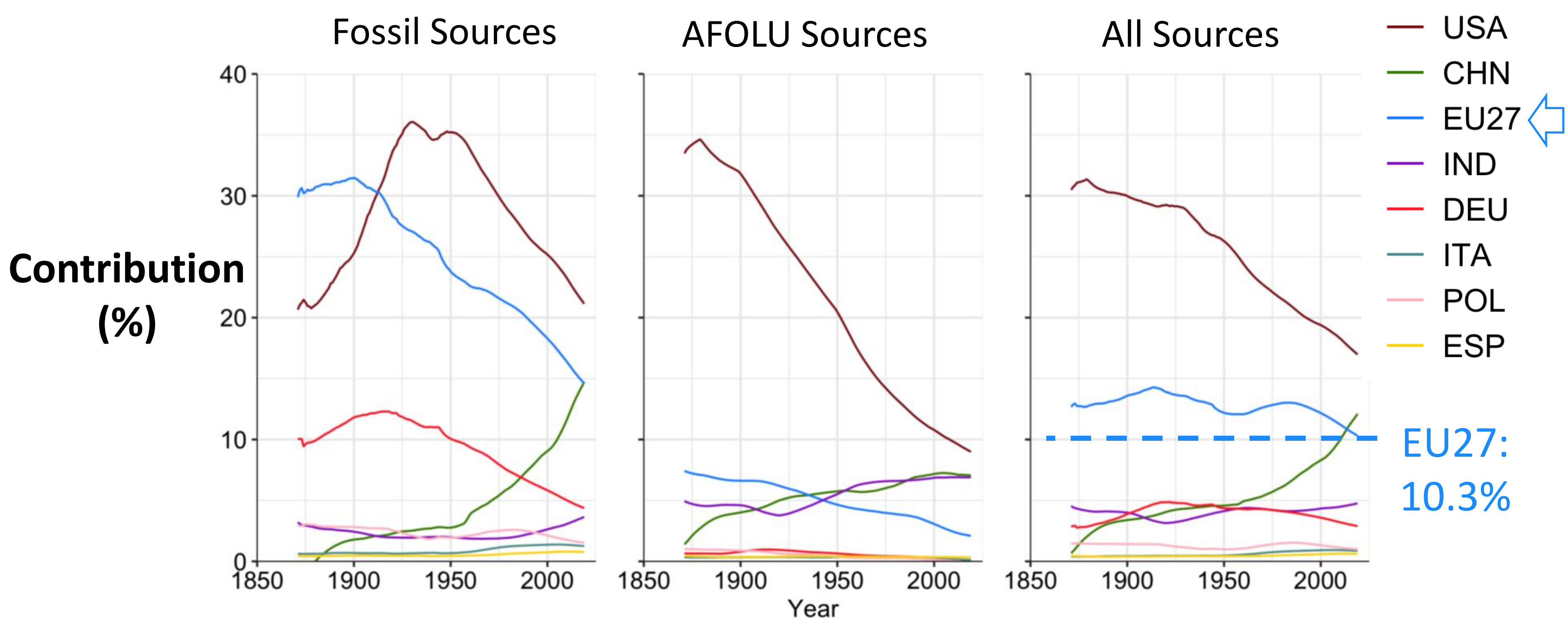
Canadell et al, IPCC AR6 chapter 5

Global Temperature Change by Gas (°C)



Jones et al., in prep.

D7.4-D7.5: EU contribution to Global Cumulative Emissions and to Warming



Jones et al., in prep.

D7.12: Report on Marketability of VERIFY products

- **Aim:** Explore Potential Commercialisation of VERIFY Project Outputs

- **Methods**
  - Consult the supply side – VERIFY products available
  - Research on demand for products
  - Identify barriers to commercialisation (incl. competition)
  - Identify enablers of commercialisation

D7.12: Report on Marketability of VERIFY products

- **VERIFY-related research themes with potential market value**
  - Timely monitoring of patterns of emissions in Europe
  - Fast-track monitoring of fossil fuel emissions at global scale
  - Monitoring CO2 and pollutants emissions from industrial point sources
  - NRT science-based emissions indicators for corporate and finance players
  - Advanced GHG tracking & targeting tool for city practitioners

  - Advanced monitoring of CH4 fugitive emissions
  - Monitoring of carbon capture and storage in forests and soil practices
  - High-resolution urban climate impacts linked to heat produced by combustions

D7.12: Report on Marketability of VERIFY products

- **Barriers to commercialisation**
  - Competition
  - Institutional structures, capability and capacity
  - Standardisation and benchmarking

- **Enabling commercialisation**
  - Partnerships/outsourcing: governments, space agencies, private companies
  - Involve partners in project/product design understand their needs
  - Actively promote outputs to potential customers
  - Data and modelling standardisation

- **Examples of good practice**
  - LSCE's Carbon Monitor & Methane Watch
  - CICERO's Spin-off Shades of Green

Reflections on VERIFY WP7 Achievements

- Did we have major input to scientific assessments?
- Did we facilitate advances to scientific methods?
- Did we generate impact beyond science?
- Did we help to shape the future research agenda?

D7.8-7.9: European research community survey: research needs for verification

Section 1 of 7

(D7.9) Survey of VERIFY scientists

Sources of uncertainty in global GHG fluxes: towards verification of atmospheric GHG concentrations and emissions.

You don't need to answer all sections - just those WPs you work on. Short (~100 word) answers are fine.

Objective & background info

Uncertainties in the strength of source and sink fluxes of greenhouse gases (GHG; CO2, CH4 & N2O) currently prevent a robust attribution of trends in atmospheric concentrations to changes in a specific flux, on a timeframe that is informative to policymakers.

Peters et al. (2017*) summarised the major uncertainties in each term of the global carbon budget, which has since been reviewed and updated annually (latest iteration: Friedlingstein et al., 2021, Table 9*).

Deliverable 7.9 aims to capture substantial sources of uncertainty identified by any VERIFY work package (MRV, CO2, CH4 or N2O fluxes, whether national or global), which should serve as a checklist for future research and inform where can we make progress in the next 5 years.

*Papers cited above are hyperlinked in the email invitation to participate in this survey.

D7.8-7.9: EUROPEAN RESEARCH COMMUNITY SURVEY: RESEARCH NEEDS FOR VERIFICATION

Key Themes

More observations	Research community interactions	More powerful simulations	Favour accuracy over completeness
Co-emitted species: CO, $^{14}CO_2$, NO_x, N_2O, HCHO, APO	Closer collaboration	Increased compute power	Target low complexity influencing total emissions
Expand ground & satellite observations	Reconcile datasets, greater comparability	Community inversion framework	CH_4 and N_2O from agriculture, LULUCF & waste

D7.8-7.9: EUROPEAN RESEARCH COMMUNITY SURVEY: RESEARCH NEEDS FOR VERIFICATION

Live Survey:

- Discuss sources of substantial uncertainty identified in this work package.
- Discuss priorities for resolving this source of uncertainty?

VERIFY

Thank you for your attention.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776810