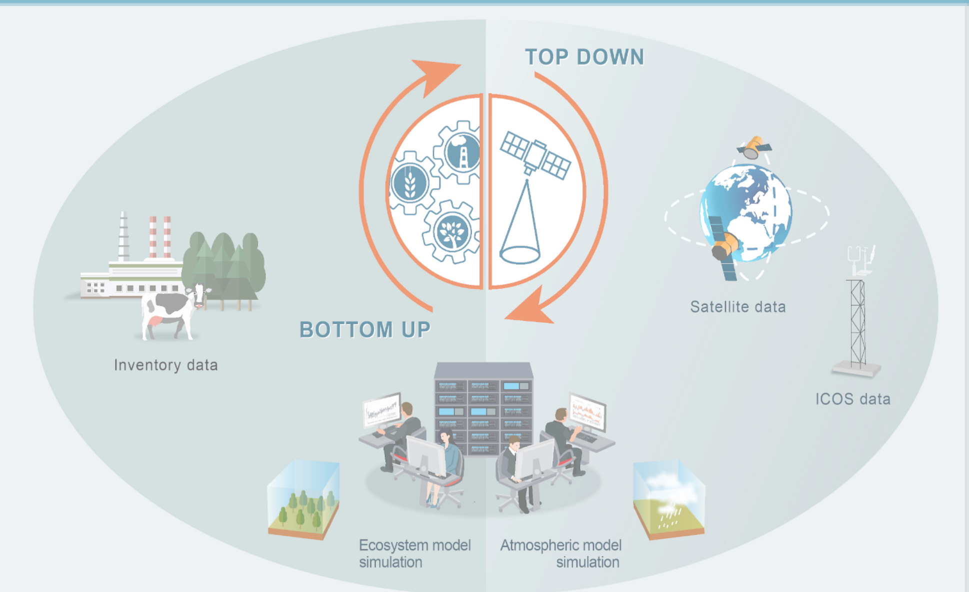
Top down and bottom up estimates of the European GHG balance

Philippe Ciais

Acknowledging all VERIFY consortium and outside contributors



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

The project

Goal : Improved estimates of GHG emissions and sinks across EU+UK using inventories and research-based approaches

Duration : From Feb 2018 to June 2022

- WP1 – Dialogue with inventory agencies
- WP2 – Fossil fuel emissions
- WP3 – Terrestrial CO2 fluxes
- WP4 – Emissions of CH4 and N2O
- WP5 – Synthesis bottom-up / top down
- WP6 – Application to other countries
- WP7 – Outreach, stakeholders engagement

MAIN PUBLICATIONS

Earth Syst. Sci. Data, 12, 961–1001, 2020
https://doi.org/10.5194/essd-12-961-2020

Open Access Earth System Science Data

European anthropogenic AFOLU greenhouse gas emissions: a review and benchmark data

Ana Maria Roxana Petrescu[1], Glen P. Peters[2], Greet Janssens-Maenhout[3], Philippe Ciais[4], Francesco N. Tubiello[5], Giacomo Grassi[3], Gert-Jan Nabuurs[6], Adrian Leip[3], Gema Carmona-Garcia[3], Wilfried Winiwarter[7,8], Lena Höglund-Isaksson[7], Dirk Günther[9], Efisio Solazzo[3], Anja Kiesow[9], Ana Bastos[10], Julia Pongratz[10,11], Julia E. M. S. Nabel[11], Giulia Conchedda[5], Roberto Pilli[3], Robbie M. Andrew[2], Mart-Jan Schelhaas[6], and Albertus J. Dolman[1]

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https://doi.org/10.5194/essd-2020-367
print. Discussion started: 17 December 2020

Open Access Earth System Science Data Discussions

The consolidated European synthesis of CH_4 and N_2O emissions for EU27 and UK: 1990-2018

Ana Maria Roxana Petrescu[1], Chunjing Qiu[2], Philippe Ciais[2], Rona L. Thompson[3], Philippe Peylin[2], Matthew J. McGrath[2], Efisio Solazzo[4], Greet Janssens-Maenhout[4], Francesco N. Tubiello[5], Peter Bergamaschi[4], Dominik Brunner[6], Glen P. Peters[7], Lena Höglund-Isaksson[8], Pierre Regnier[9], Ronny Lauerwald[9,23], David Bastviken[10], Aki Tsuruta[11], Wilfried Winiwarter[8,12], Prabir K. Patra[13], Matthias Kuhnert[14], Gabriel D. Orregioni[4], Monica Crippa[4], Marielle Saunois[2], Lucia Perugini[15], Tiina Markkanen[11], Tuula Aalto[11], Christine D. Groot Zwaaftink[3], Yuanzhi Yao[16], Chris Wilson[17,18], Giulia Conchedda[5], Dirk Günther[19], Adrian Leip[4], Pete Smith[14], Jean-Matthieu Haussaire[6], Antti Leppänen[20], Alistair J. Manning[21], Joe McNorton[22], Patrick Brockmann[2] and Han Dolman[1]

https://doi.org/10.5194/essd-2020-376
Preprint. Discussion started: 18 December 2020

Open Access Earth System Science Data Discussions

Earth Syst. Sci. Data, 12, 1–29, 2020
https://doi.org/10.5194/essd-12-1-2020

Open Access Earth System Science Data

The consolidated European synthesis of CO_2 emissions and removals for EU27 and UK: 1990-2018

Ana Maria Roxana Petrescu[1], Matthew J. McGrath[2], Robbie M. Andrew[3], Philippe Peylin[2], Glen P. Peters[3], Philippe Ciais[2], Gregoire Broquet[2], Francesco N. Tubiello[4], Christoph Gerbig[5], Julia Pongratz[6,7], Greet Janssens-Maenhout[8], Giacomo Grassi[8], Gert-Jan Nabuurs[9], Pierre Regnier[10], Ronny Lauerwald[10,11], Matthias Kuhnert[12], Juraj Balkovič[13,14], Mart-Jan Schelhaas[9], Hugo A. C. Denier van der Gon[15], Efisio Solazzo[8], Chunjing Qiu[2], Roberto Pilli[8], Igor B. Konovalov[16], Richard Houghton[17], Dirk Günther[18], Lucia Perugini[19], Monica Crippa[9], Raphael Ganzenmüller[6], Ingrid T. Luijkx[9], Pete Smith[12], Saqr Munassar[5], Rona L. Thompson[20], Giulia Conchedda[4], Guillaume Monteil[21], Marko Scholze[21], Ute Karstens[22], Patrick Brokmann[2] and Han Dolman[1]

A comparison of estimates of global carbon dioxide emissions from fossil carbon sources

Robbie M. Andrew

CICERO Center for International Climate Research, Oslo 0349, Norway

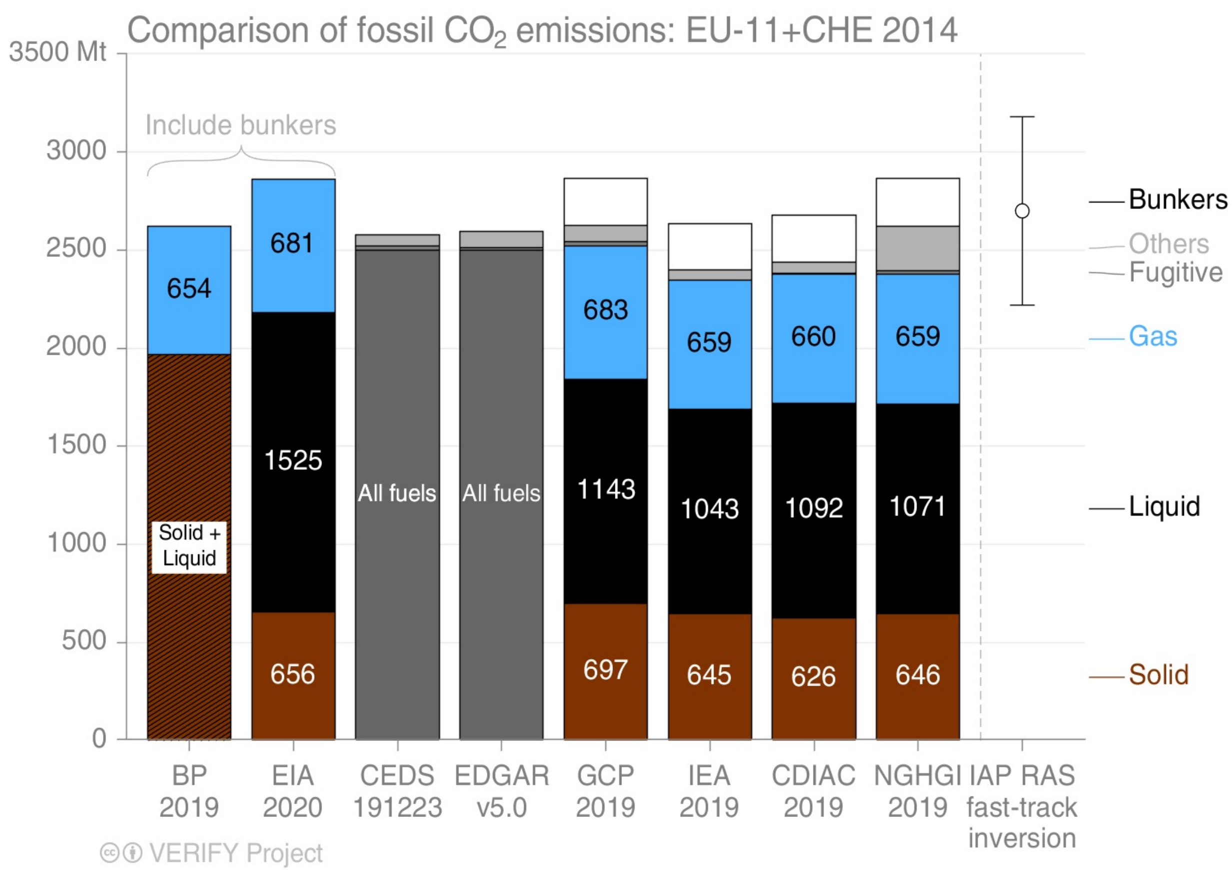
Calculating emissions

- Energy statistics, energy contents and emission factors
  - Currently IPCC defaults
  - Could switch to reported factors
- Scale to GCP estimates
  - For EU countries, these are taken directly from official reporting (CRF)
  - For some countries estimates are poor (e.g., NLD), but for EU this scale factor is often very close to unity
- Scale factor for last year with official data used for current year

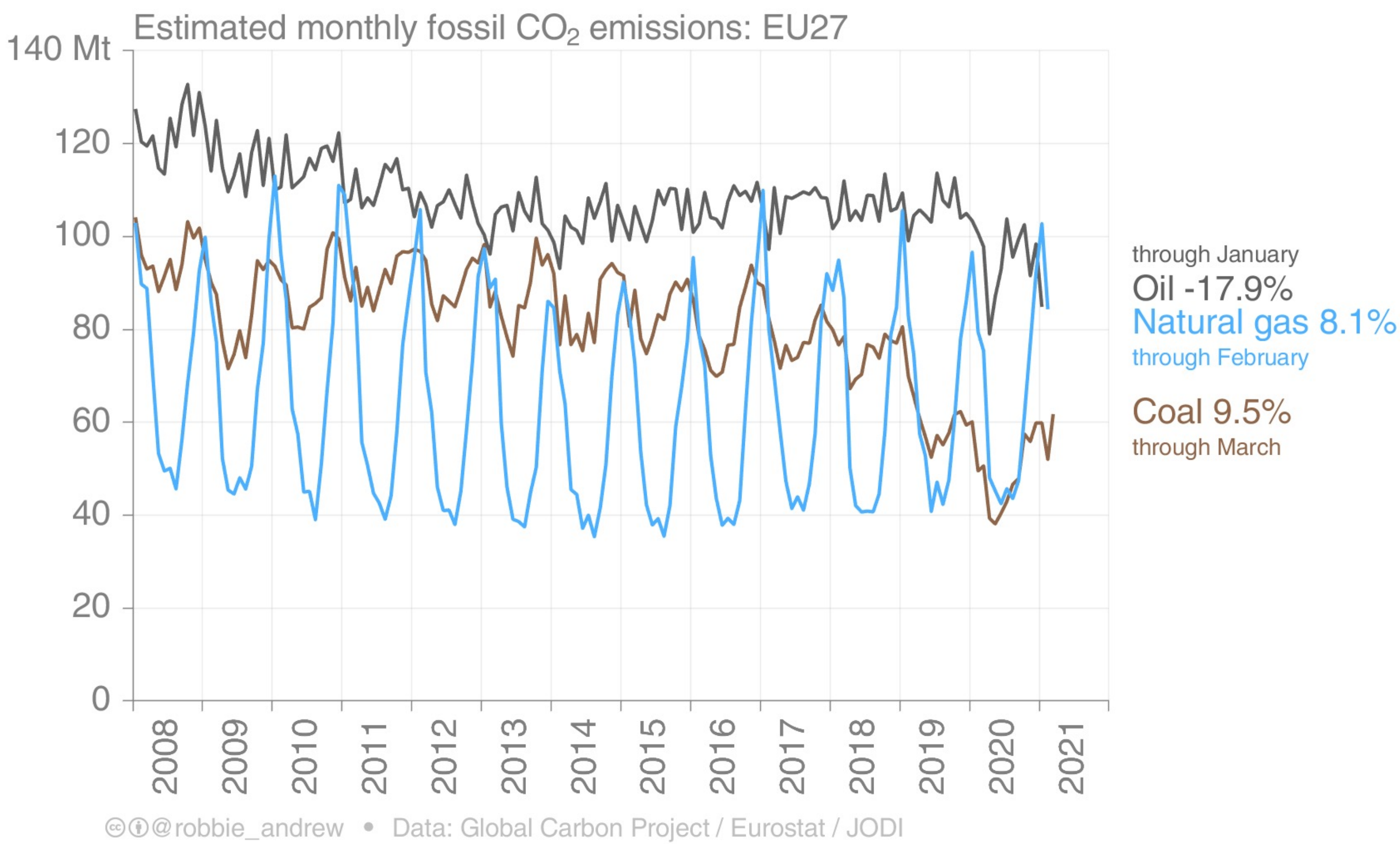
RESULTS – CO_2 SYNTHESIS

CO_2 fossil

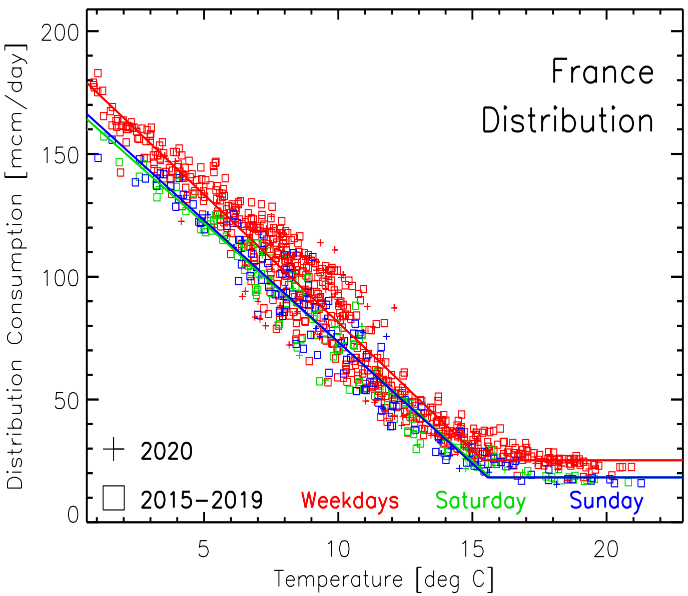
- Uncertainties in fossil CO_2 emissions estimates are 1-4% for the EU27+UK
- Differences are mainly due to system boundary issues
- The single fast track inversions gives credible estimates for the EU11+CHE (right), but with large uncertainty (~17%)



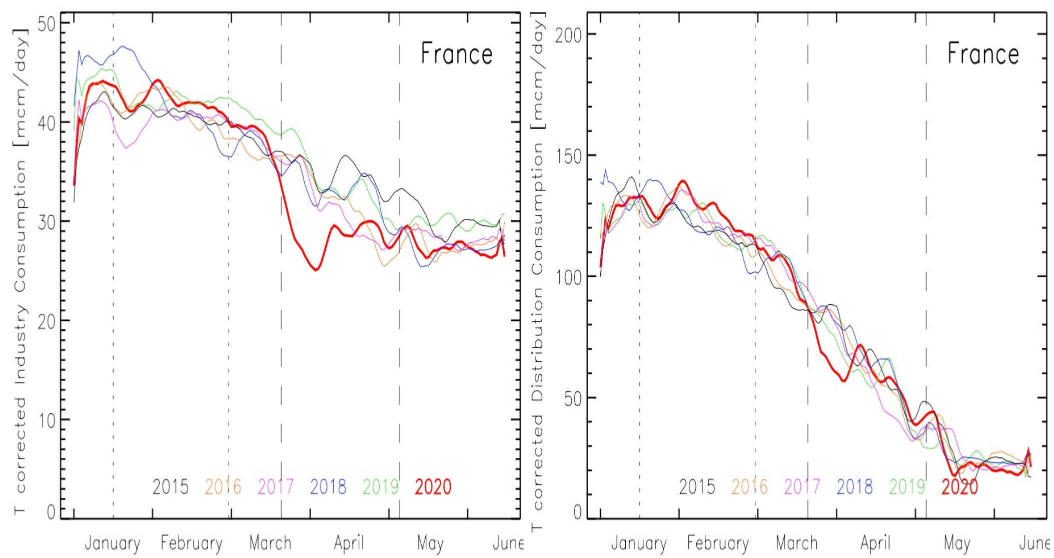
Towards monthly emission estimates



Impact of lockdowns and winter temperatures on natural gas consumption in Europe

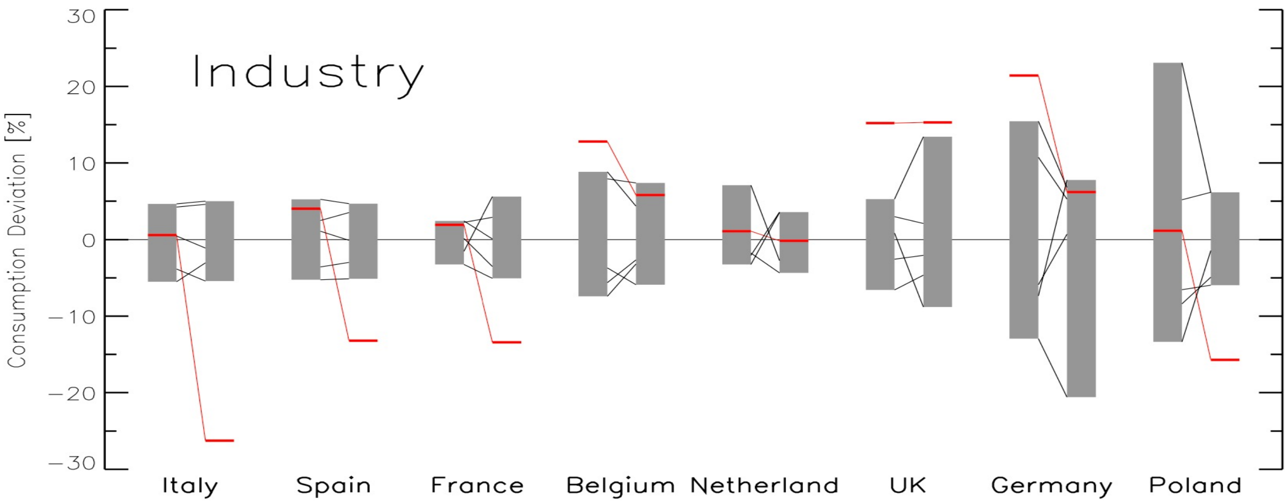


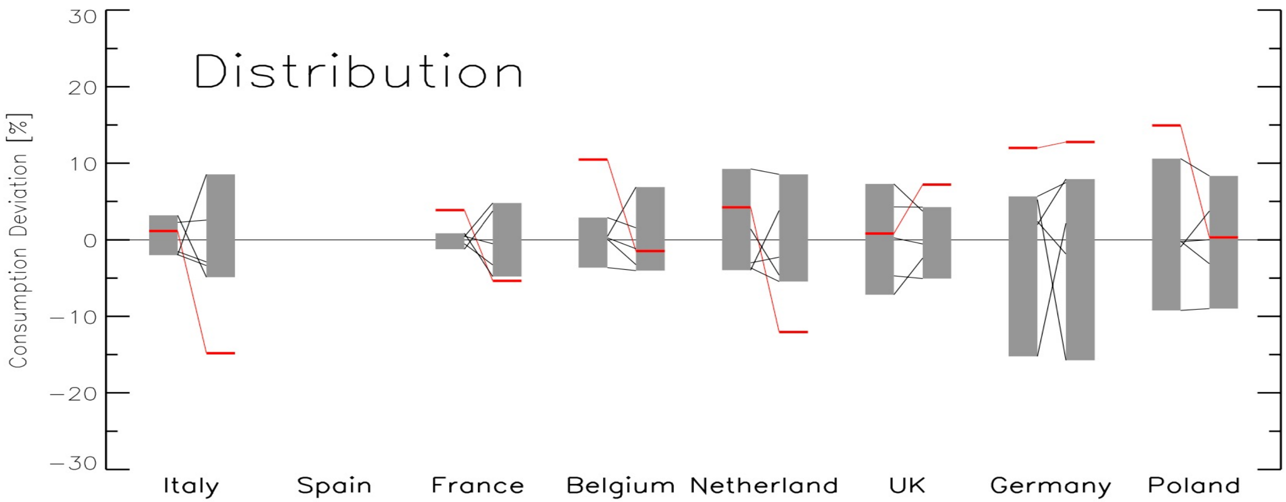
Natural gas emissions vs. lagged air temperature



Natural gas emissions changes after removing temperature effects

Changes from Jan-Feb to Mar-May

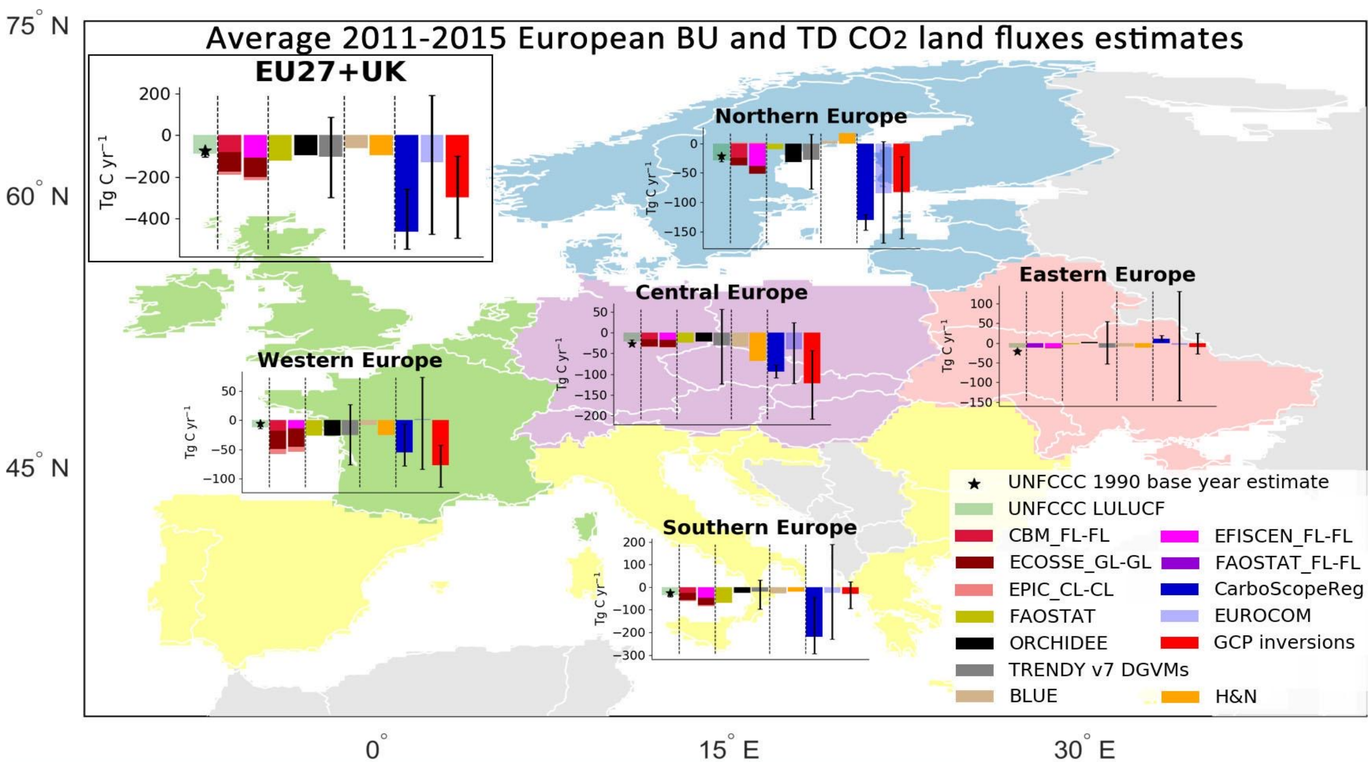




RESULTS

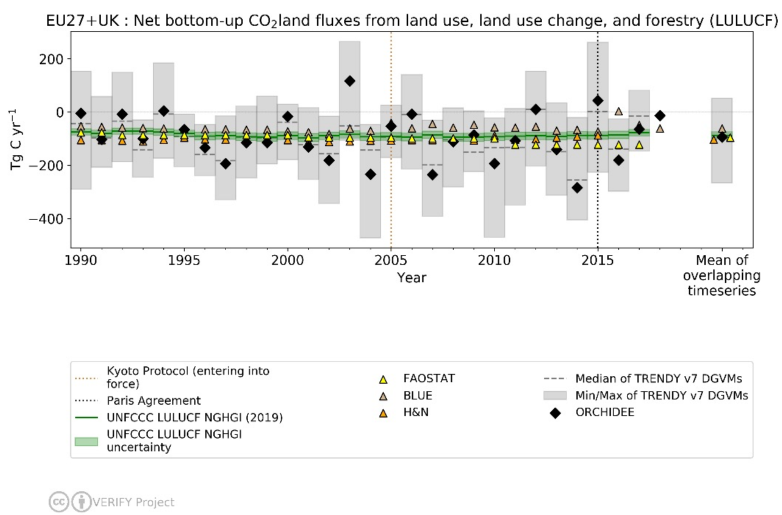
CO_2 land fluxes

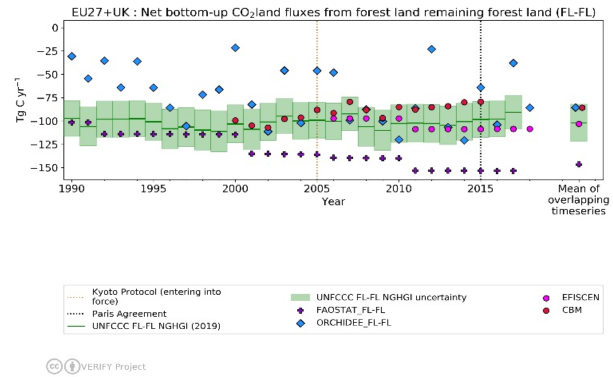
- Overall, for our five selected European regions, the CO_2 land 5-year flux averages show high variability between BU and TD estimates
- Differences we see between regions' TD and BU results are linked to model-specific set-ups and definition issues

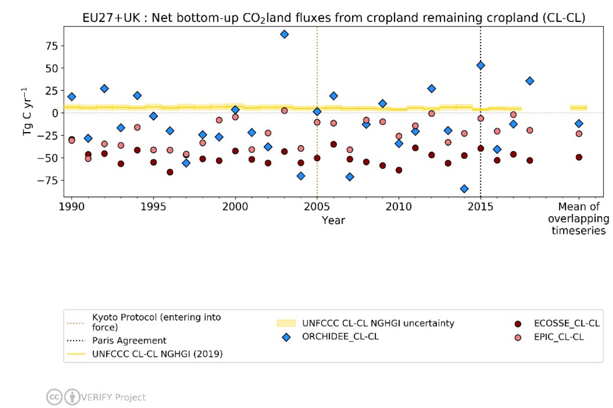


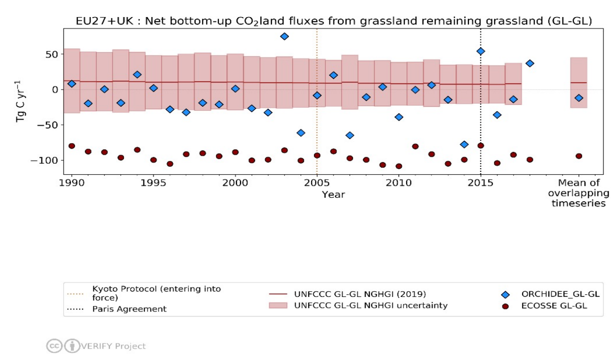
Results (continued)

- The EU27+UK land-use emissions (NGHGI) have remained relatively flat since 1990, given uncertainties.
- Sector specific models produce estimates for Forest, Croplands and Grasslands
- These bottom-up methods agree in general on average well with the NGHGI estimates.
- Differences occur when vegetation models (e.g. ORCHIDEE, DGVMs) that are driven by daily/hourly weather produce much more inter-annual variability than traditional stock change methods.



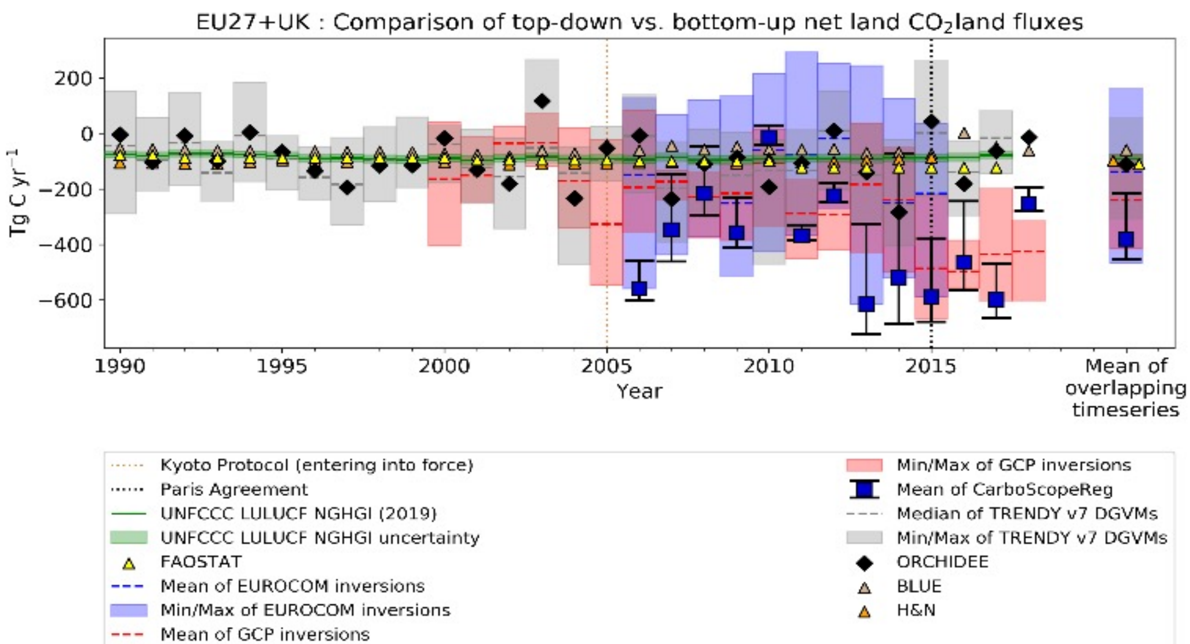






RESULTS (CONTINUED)

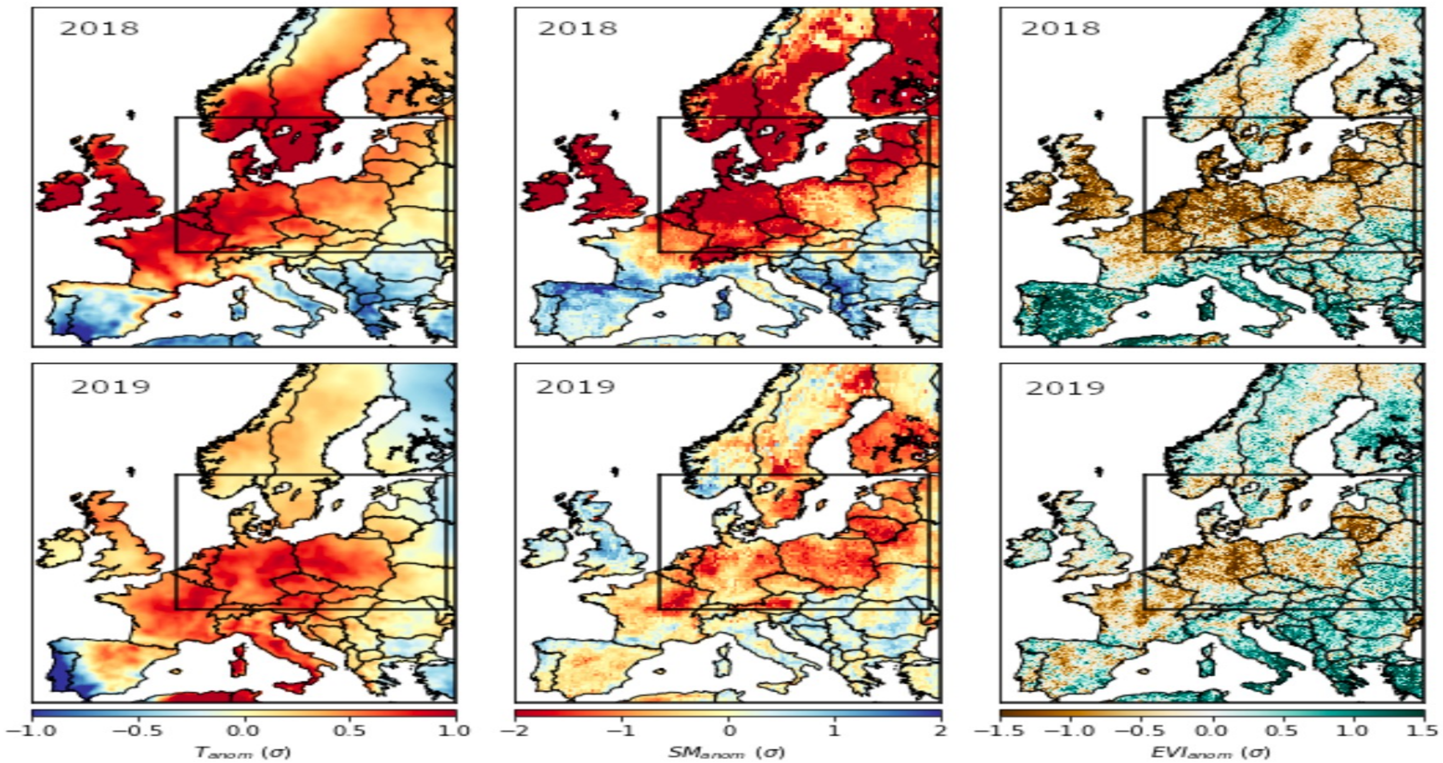
- Inversion methods for CO_2 land show much more variability than the NGHGI, but ensembles of European inversions show good agreement with the average.
- There are large uncertainties due to atmospheric transport modelling and uncertainty inherent to the limitation of the observation network.
- These models are mainly designed for large scale flux estimates and are still developing their lateral boundary regional conditions.



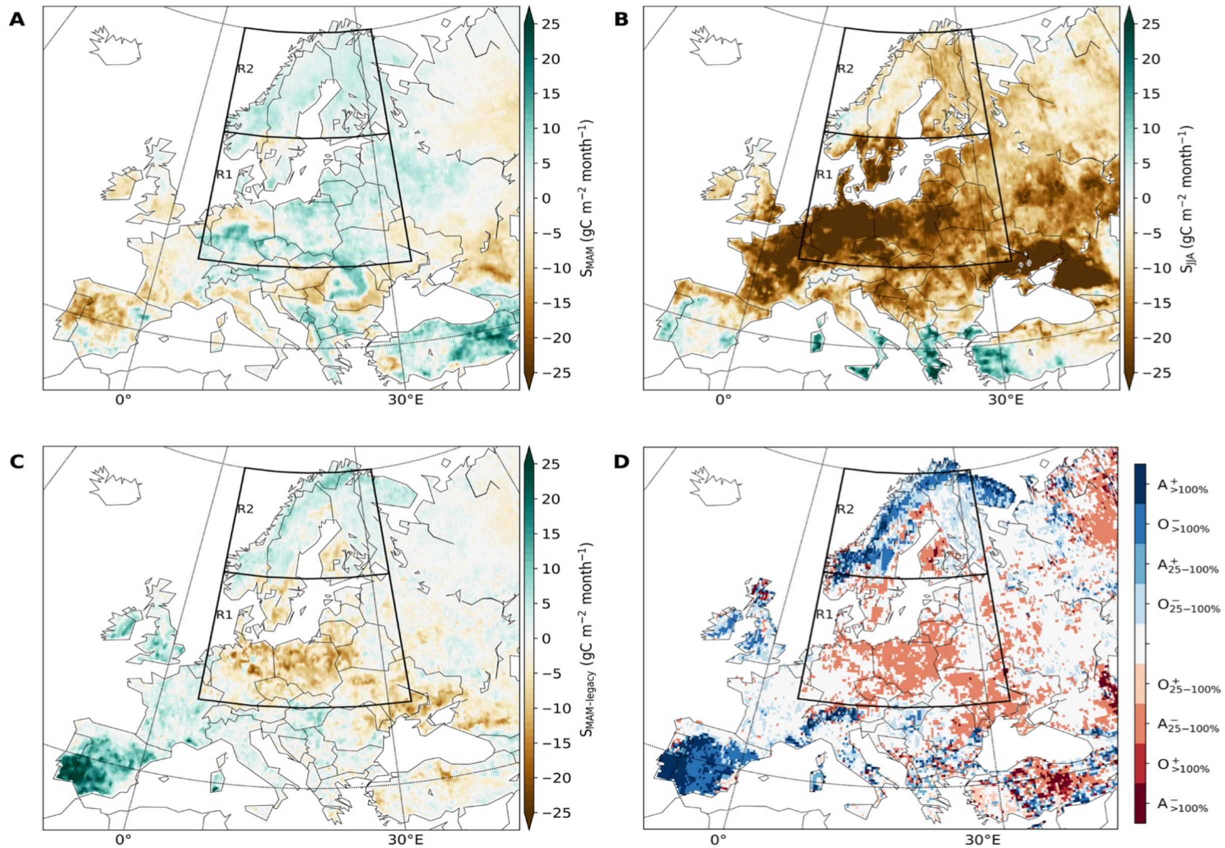
RESULTS

Analysis of legacy effects of recent <u>extreme</u> droughts in Europe:

- Seasonal effects: spring drought higher uptake -> Summer and Autumn uptake deficit
- Annual effects: double drought in 2018 and 2018 -> some ecosystems with a non-linear ‘collapse’ behaviour

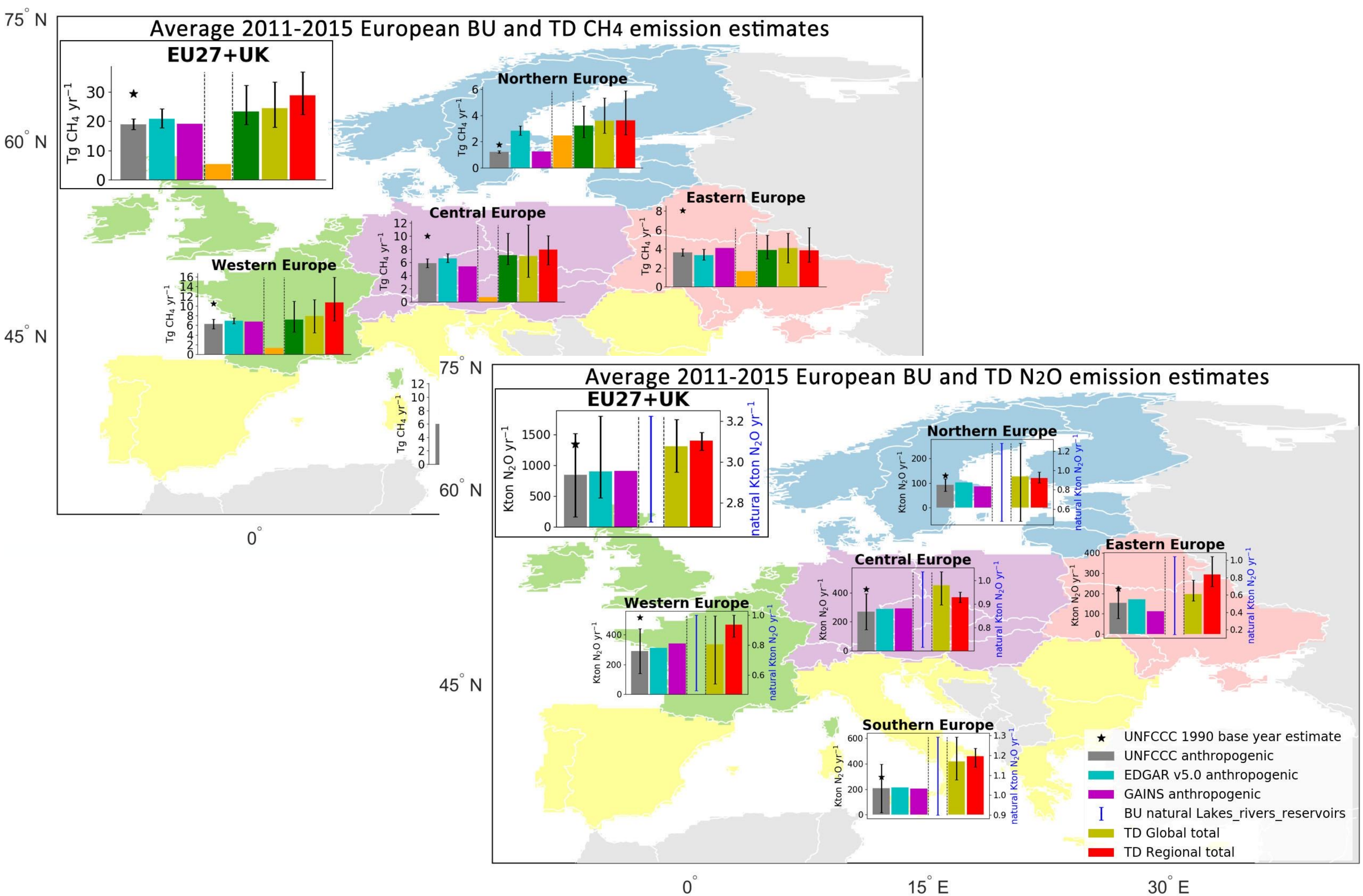


DIRECT AND LEGACY CO2 FLUX RESPONSE



Direct and legacy effects of spring and summer climate to the drought-2018 carbon balance. Spatial distribution of the average net effect of (A) spring climate anomalies direct impact on spring NBP (MAM), (B) summer climate anomalies direct impact on summer NBP (JJA), (C) spring-> summer climate legacy effects from MAM -> JJA, and (D) relative carry-over impact of spring climate to summer NBP anomalies compared to the direct impact of summer climate to summer NBP anomalies (on a relative scale, red means a negative spring -> summer NBP carry over and blue means a positive one).

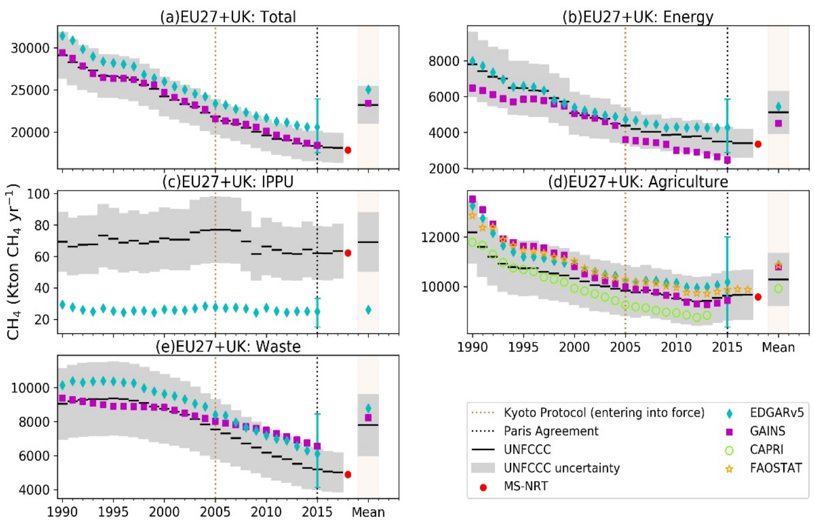
RESULTS – CH_4 AND N_2O EMISSIONS

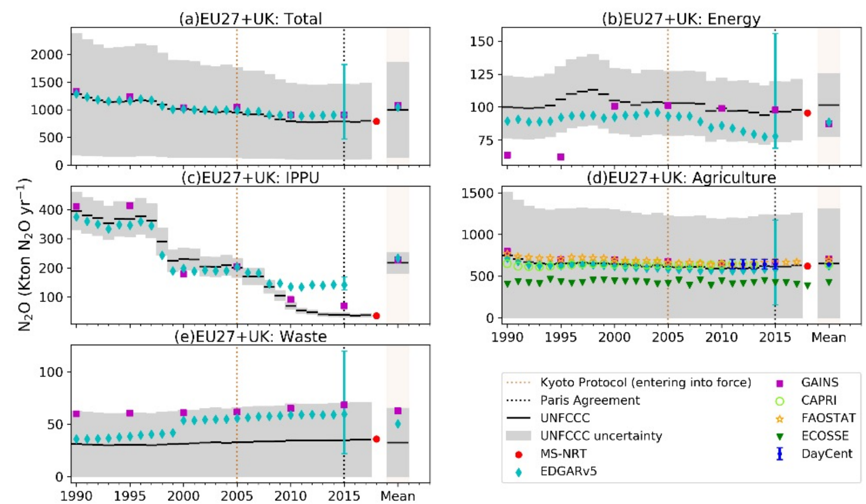


VERIFY

CH_4 AND N_2O – BU

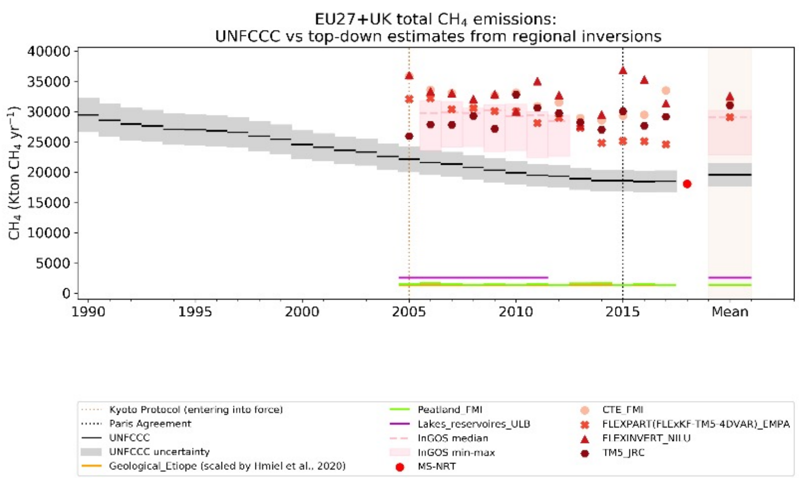
- Good agreement between BU sources
- The NGHGI data shows decreasing trends in CH_4 emissions (average 2011-2015 reported 35% reduction for the European Union with respect to the 1990 base year value) with Energy and Waste having the highest reduction shares.
- Agriculture shows the best fit between the BU estimates, all within the 10% uncertainty reported by NGHGI.

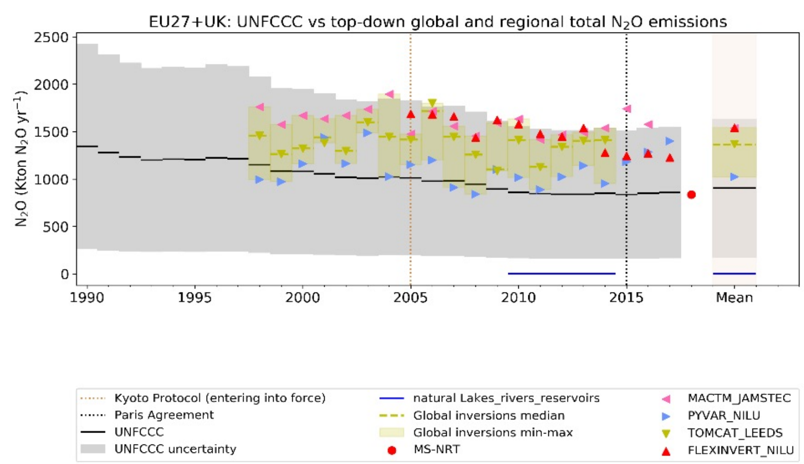




CH_4 AND N_2O – TD

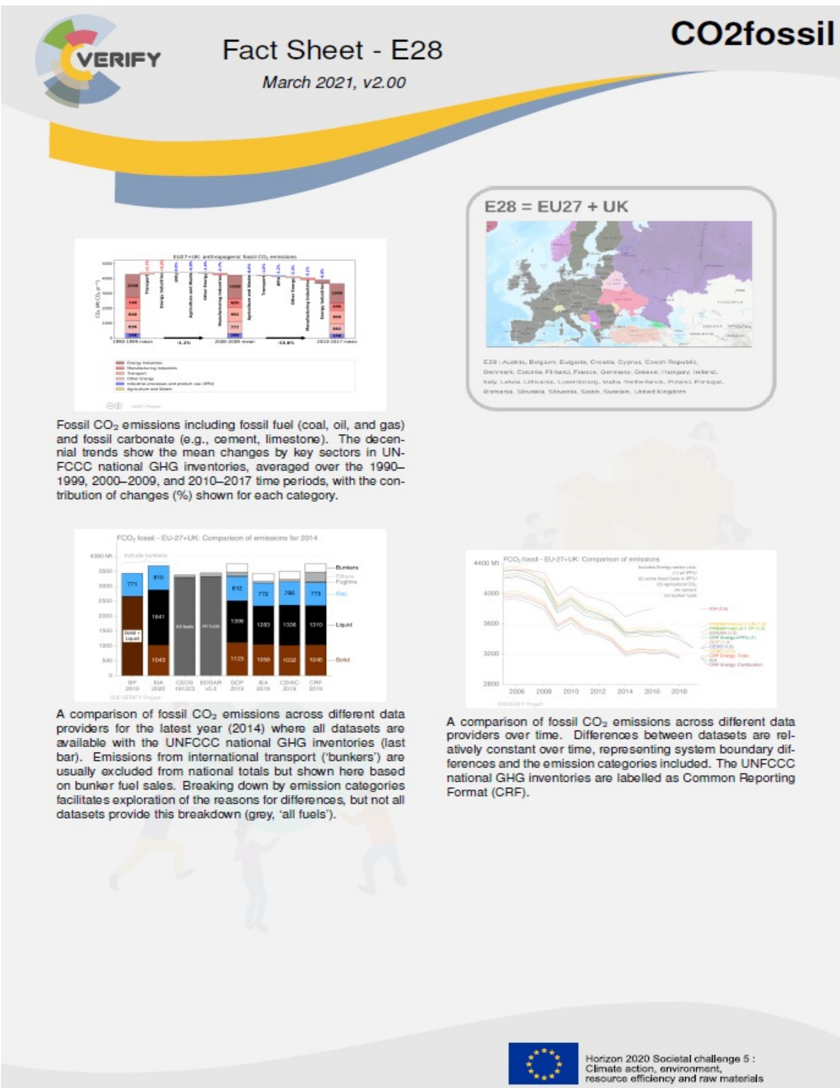
- For the use of TD as verification and complementarity tools, at both global and regional level, we need better quantification of emissions when explaining the differences between anthropogenic BU and total TD estimates.
- For *N_2O emissions* the gap observed between BU and TD estimates could be explained (~13%) from N_2O emissions from natural soils.
- Improvement of inverse methods for N_2O is needed to determine the total level of emissions and, most importantly, the trends, looking as well at seasonality variations/emissions to sector allocation.

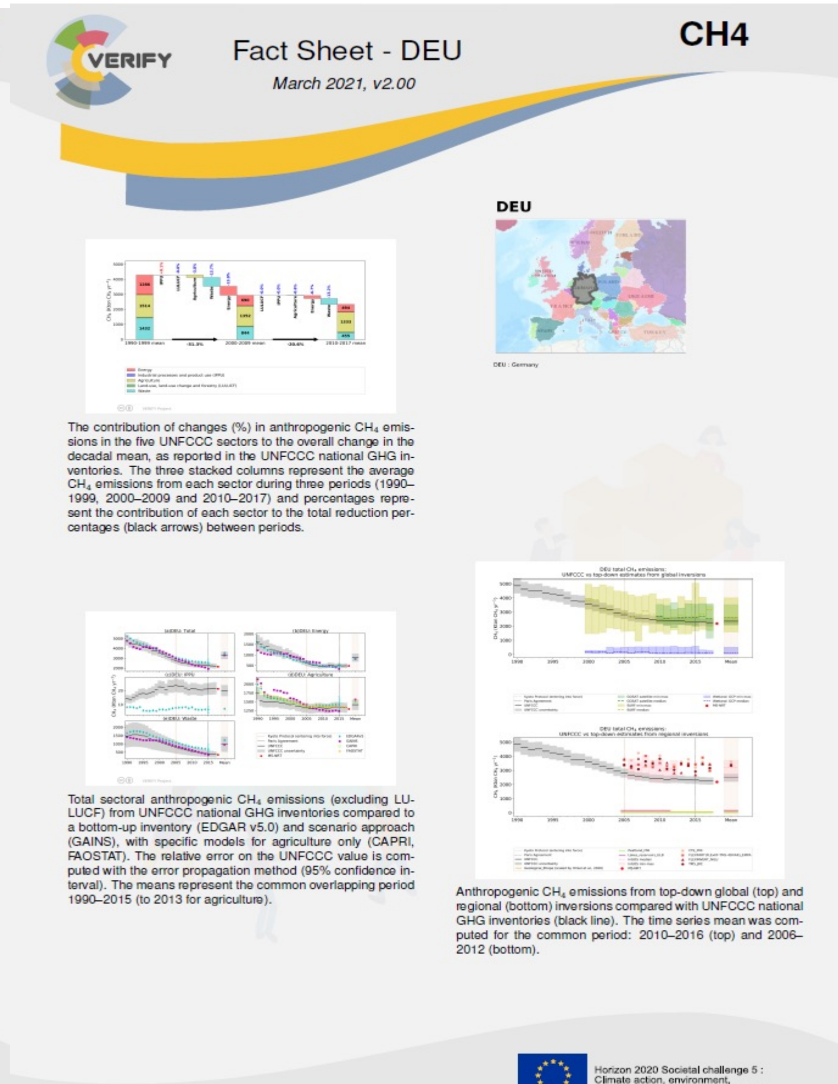




Examples of countries factsheets

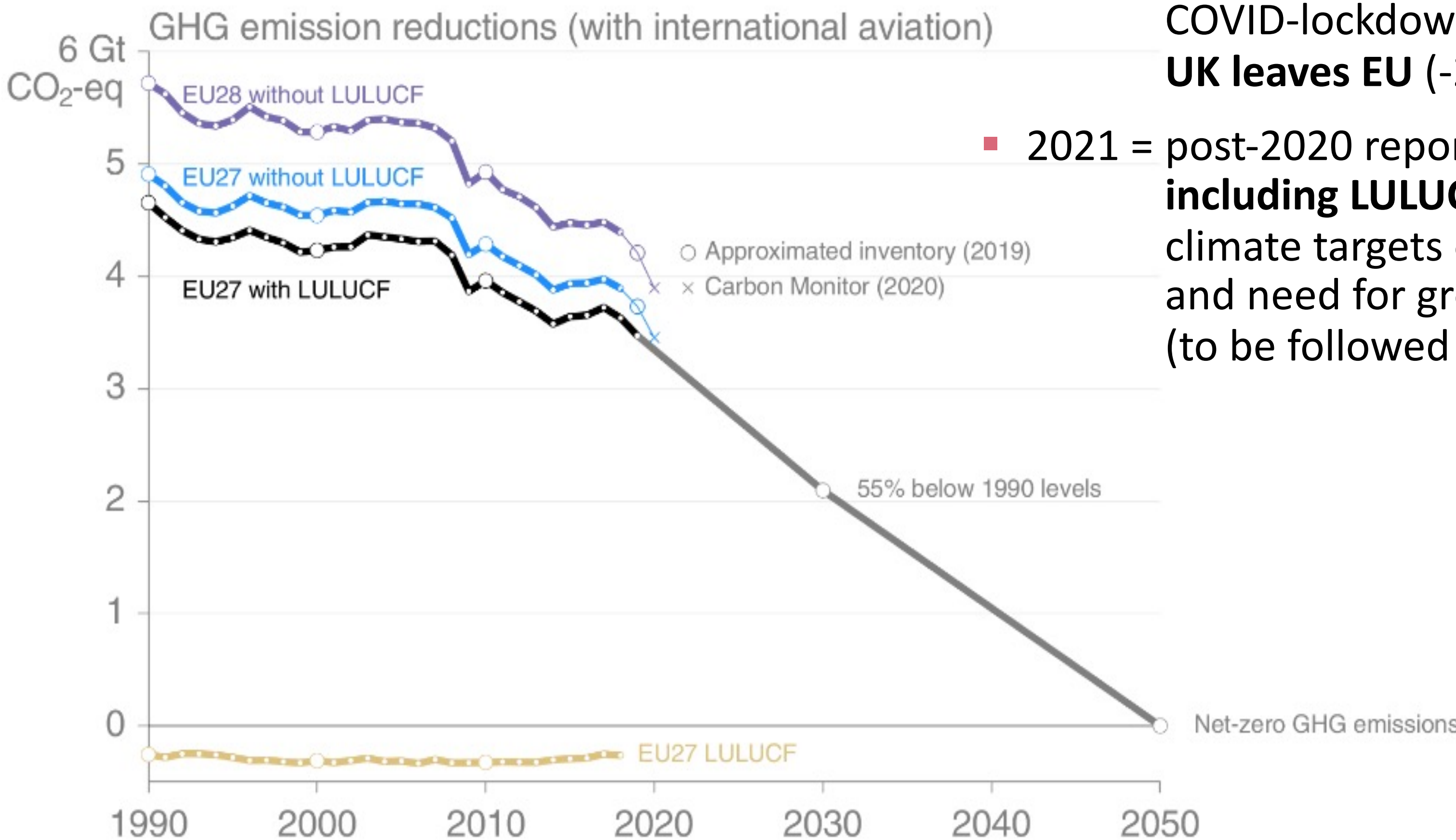
Factsheets (4 deliverables) follow each of the reconciliations and compare against UNFCCC NGHGI
Automation: 80 countries/regions, 4 fact sheets each, over 320 individual factsheets (**demo to come**)





Results – EU and USA factsheets

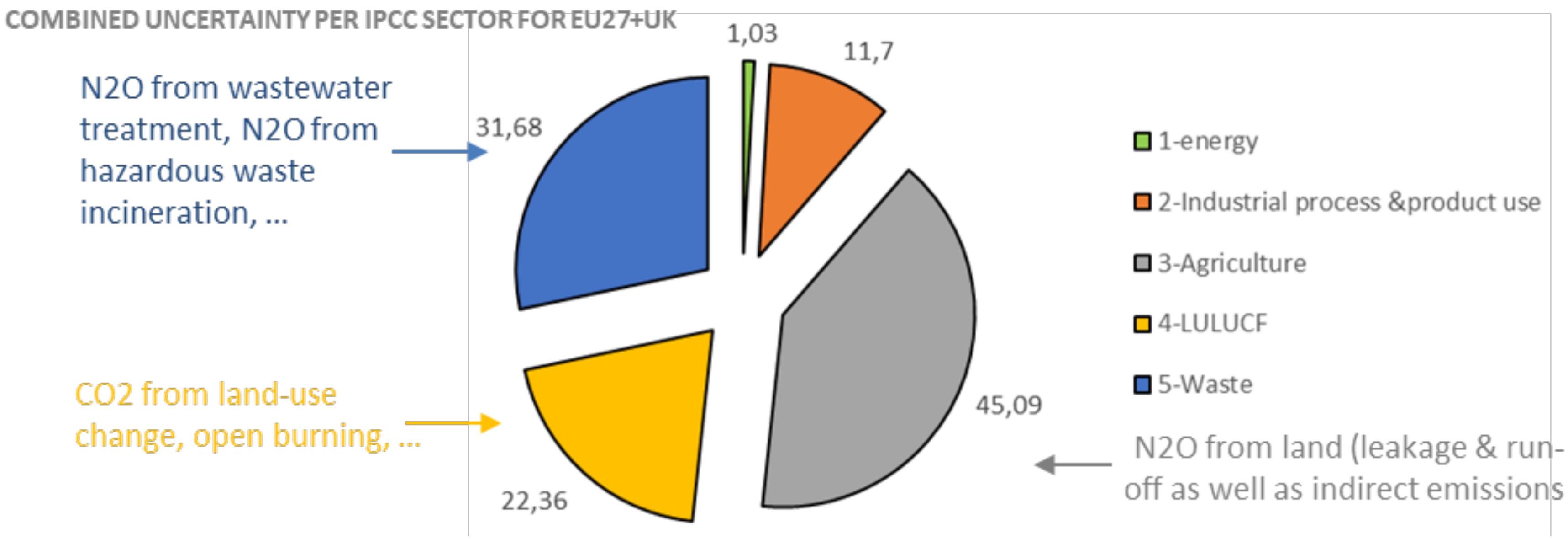
Factsheets for EU policymakers (JRC)



- 2020 = end KP period
  COVID-lockdown (impact ~10%)
  UK leaves EU (-23.2% ⇒ -20.7%)
- 2021 = post-2020 reporting scheme,
  including LULUCF for 2030
  climate targets of -55%
  and need for green recovery
  (to be followed “near real time”)

Results (continued)

EU Factsheet and best practices for GHG inventories (JRC)



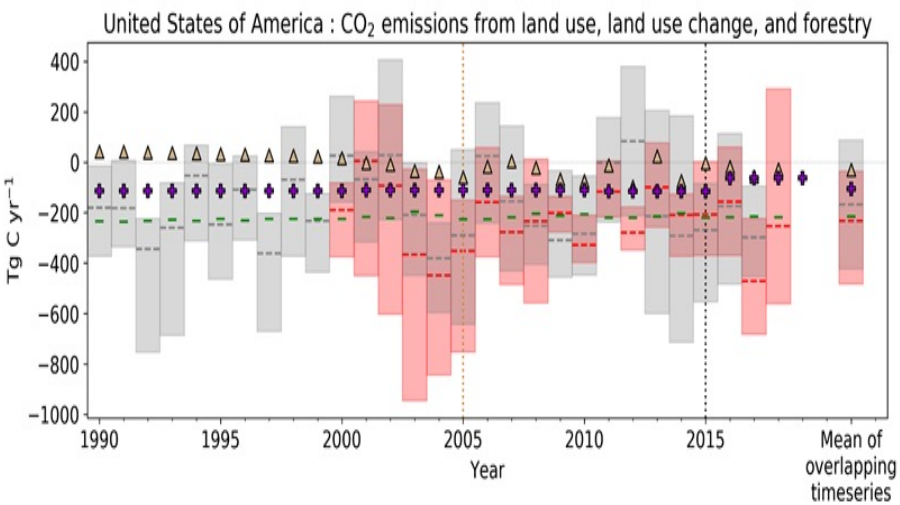
- Higher spatial and temporal resolution of the GHG inventories (NRT tracking?)
- More uptake of top-down information for assessing uncertain CH_4 and N_2O and CO_2 land emissions
- Combining information collected under different regulations: ETS 2003/87/EC, ESD 2009/406/EC, MMR 2013/525/EU, EED 2021/27/EU, EBD 2018/844/EU, FQD 1998/70/EC, MMR+ 2018/1999/EU, ESD+ 2018/842/EU, ETS+ 2019/1842/EU, Road 2009/443/EC + 2011/510/EU + 2018/956/EU + 2019/1242/EU, LULUCF 2018/841/EU, EPRTR 2006/166/EC+2019/1010/EU, AQD 2008/50/EC, NECD 2016/2284/EU, MCP 2015/2193/EU, IED 2010/75/EU

![VERIFY logo]

RESULTS (CONTINUED)

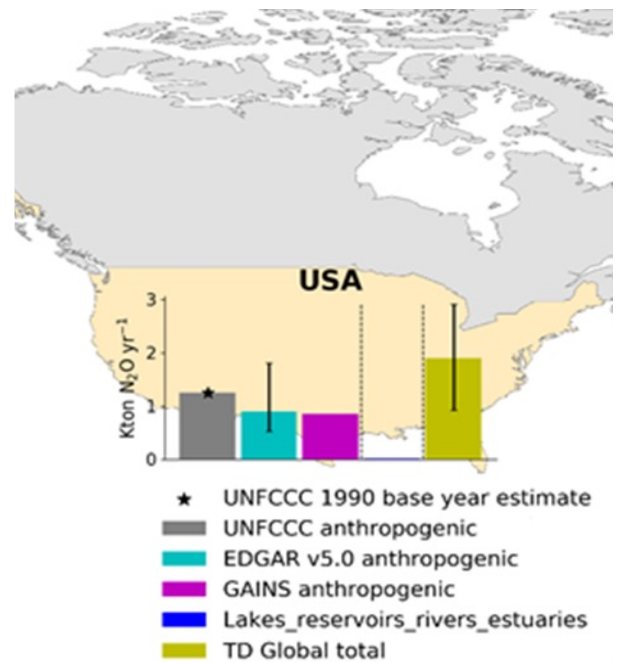
USA factsheets

CO_2 land



- Unknown fraction of unmanaged land was brought up by US EPA

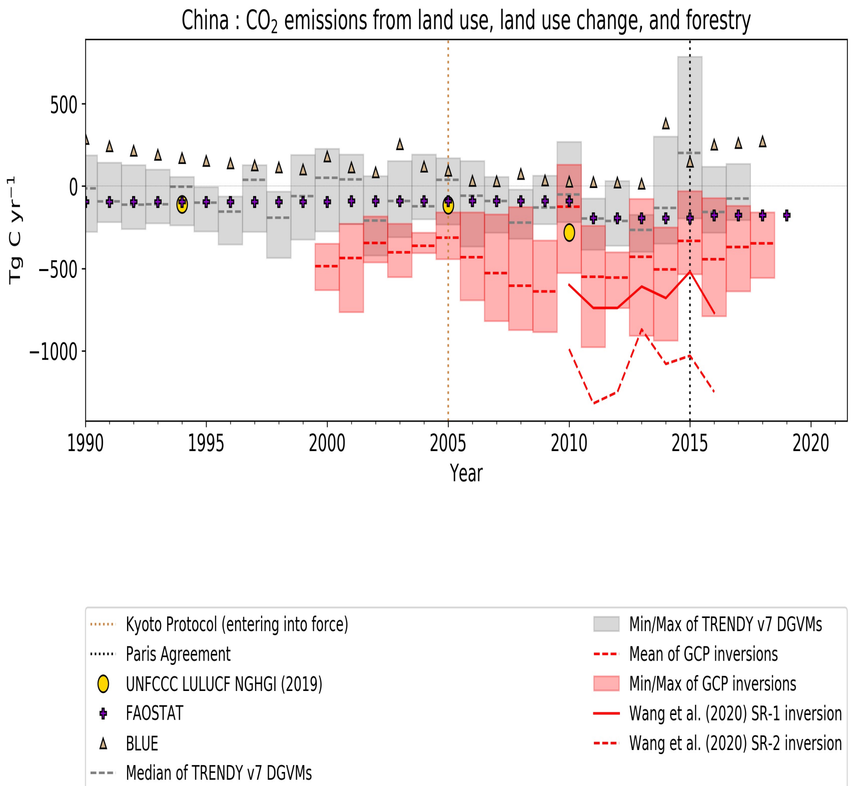
N_2O



- Large uncertainty because of the seasonality and natural component of the emissions

CHINA factsheets

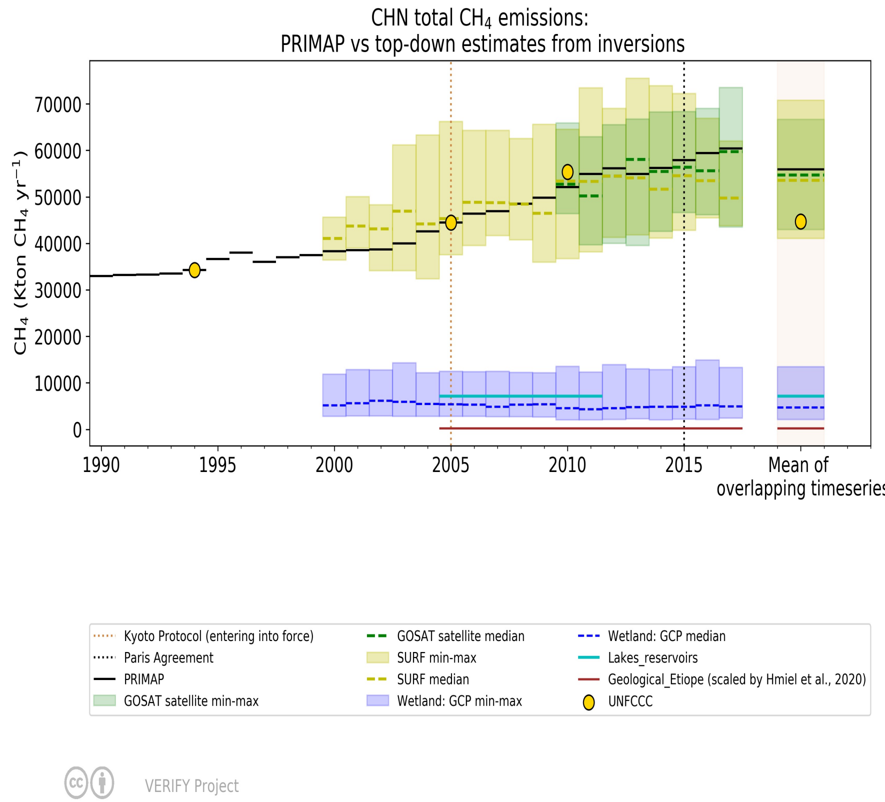
CO_2 land



- Global inversion of Wang with extra 4 flux towers in China and 1 in Siberia

Generally, inversions give a higher land CO_2 uptake that carbon stocks increase from inventories

CH_4

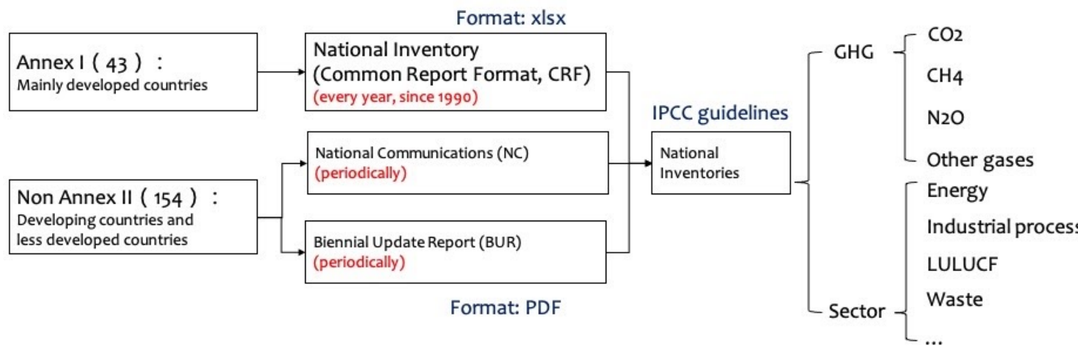


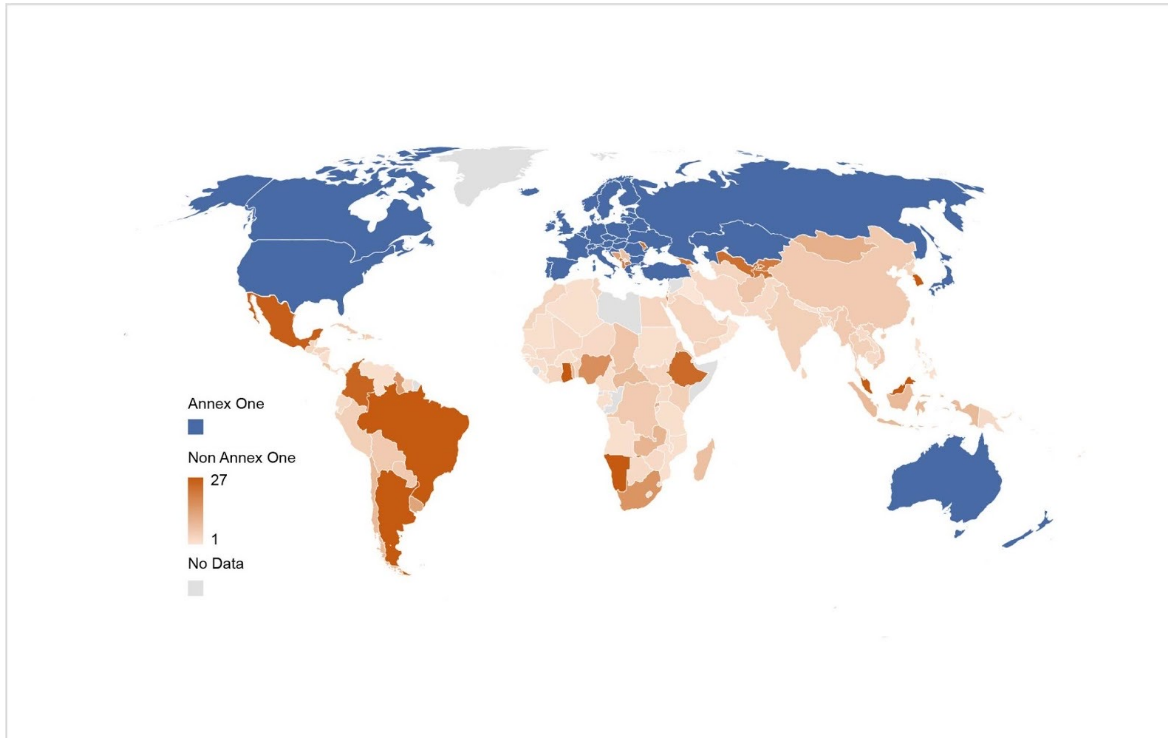
- Global inversions of Saunois with data from SURF and GOSAT, not yet TROPOMI

Fair agreement of total anthropogenic with last national communication. Agreement breaks down for sectors that inversions have problems to separate

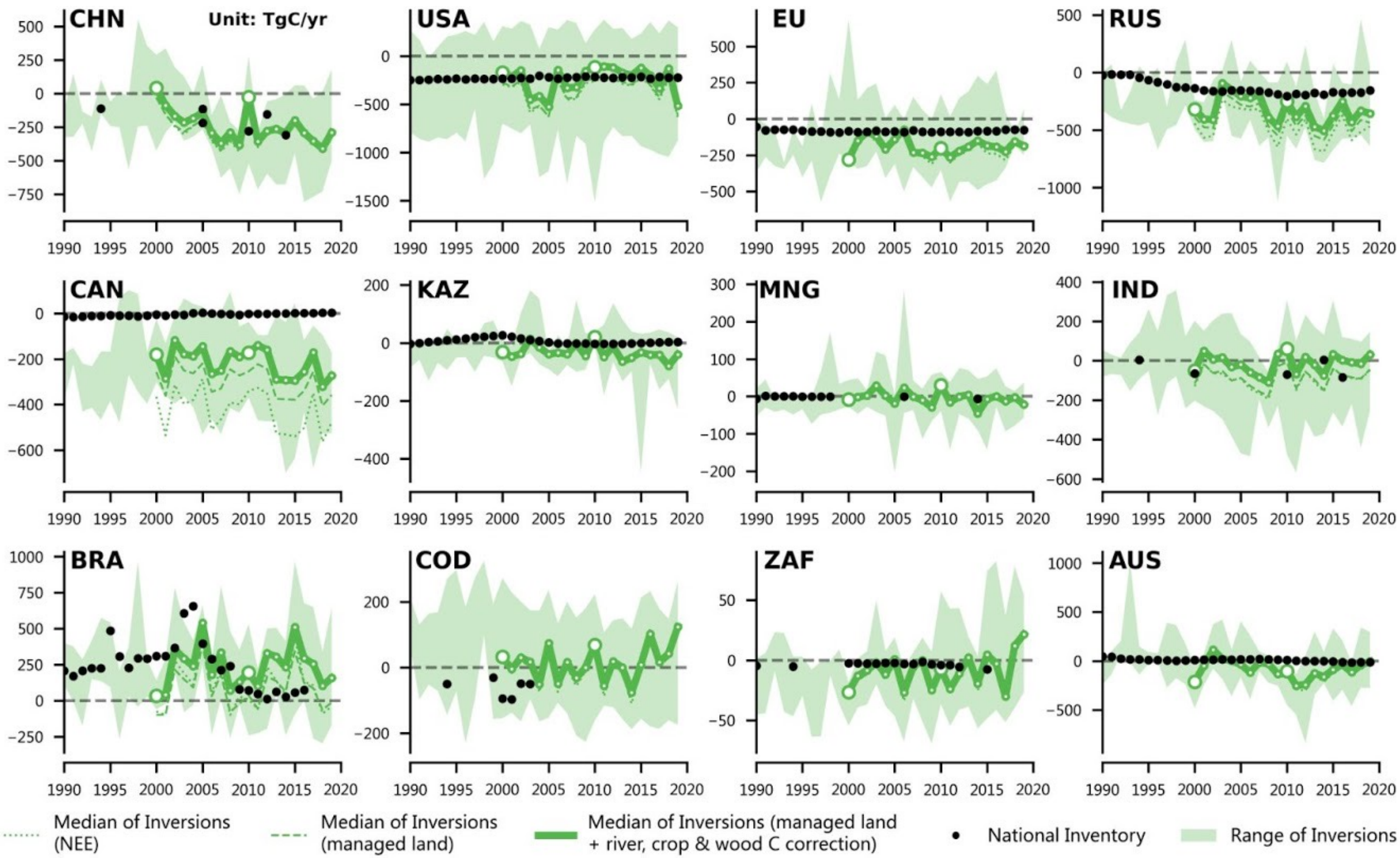
GLOBAL INVENTORIES – INVERSIONS

- Global database of UNFCCC reports manually compiled and harmonized (BUR, NC, CRF)
- Corrections made on CO2 fluxes (trade, rivers, managed lands)

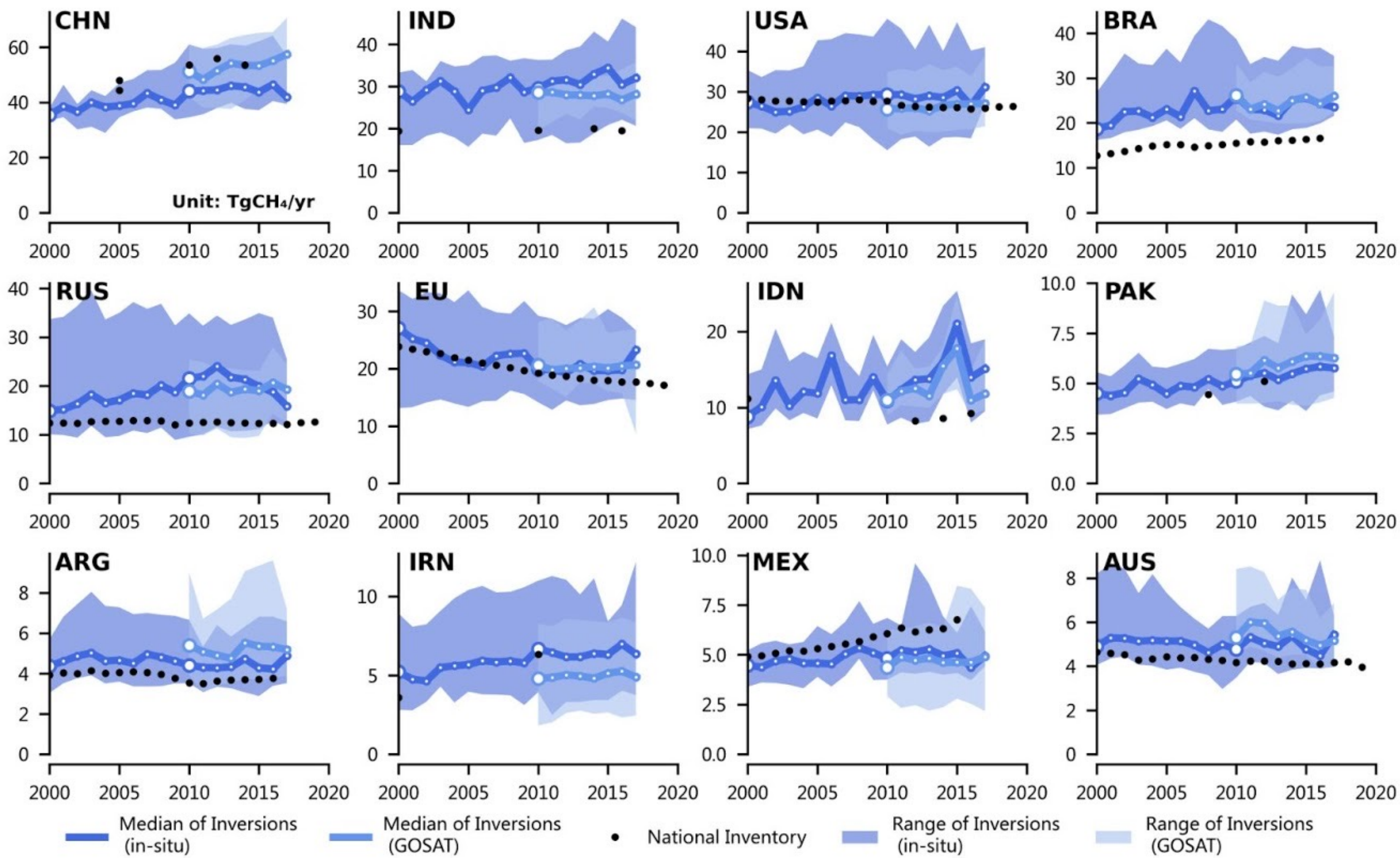




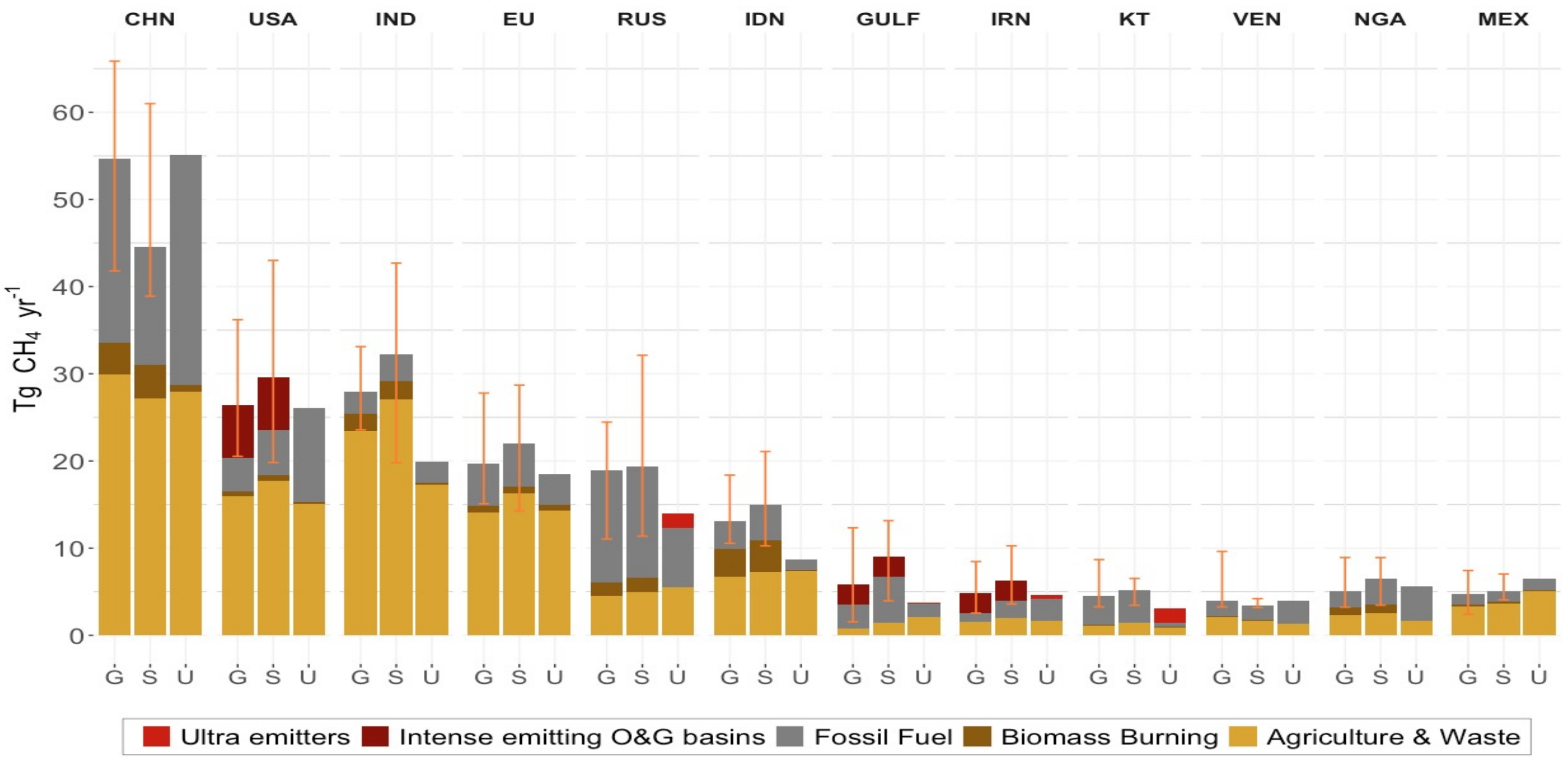
GLOBAL INVENTORIES – INVERSIONS – CO2



GLOBAL INVENTORIES – INVERSIONS – CH4

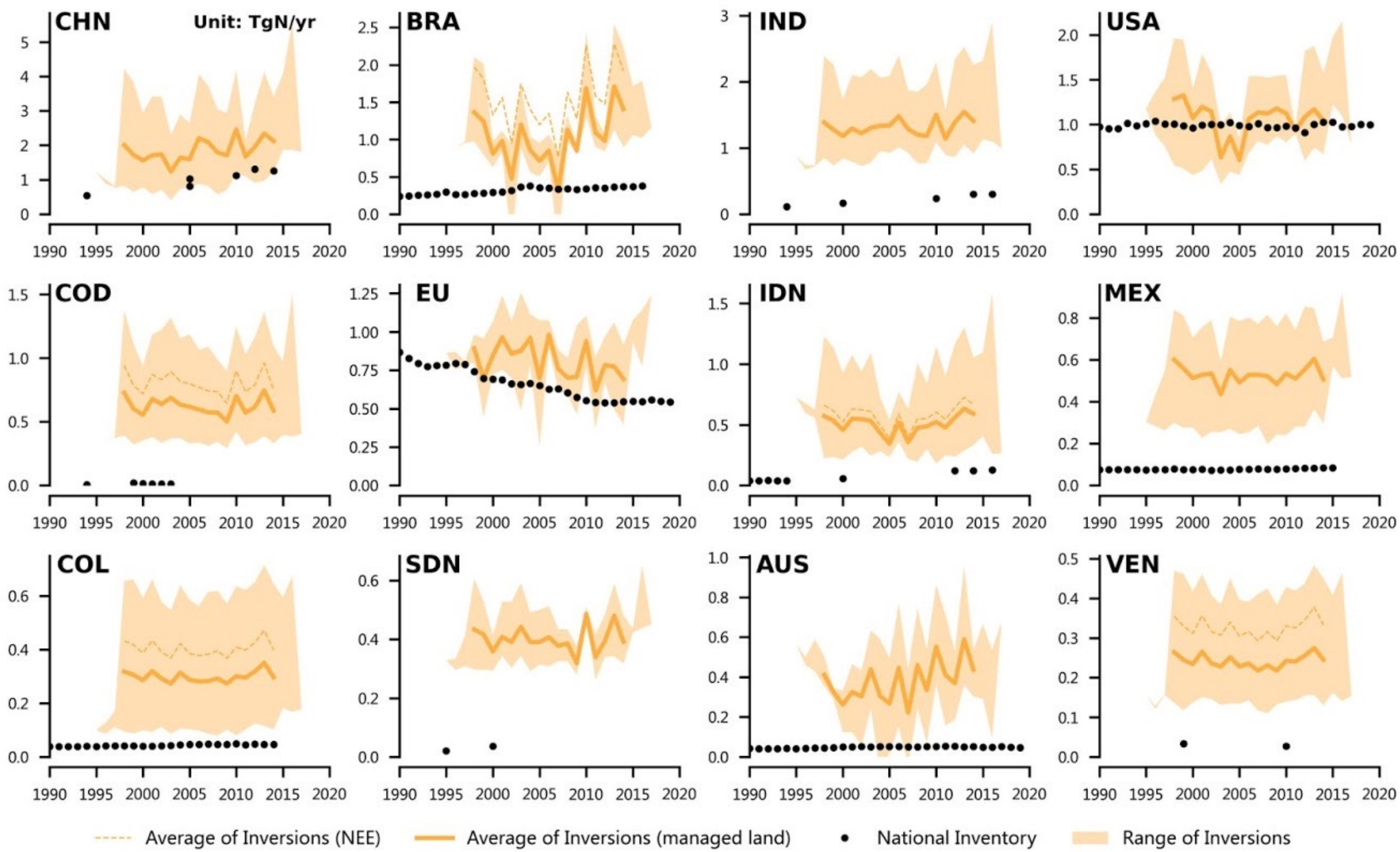


GLOBAL INVENTORIES – INVERSIONS – CH4



Added the contribution of intense emission basins (regional Tropomi inversions for Koweit, Ahvaz, Permian) and of ultra emitters (sporadic accidendal links > 30 tCH4 h-1)

GLOBAL INVENTORIES – INVERSIONS – N2O



- per gas reporting vs. CO_2eq reporting?
- annual, biannual or 5-year averages, or all?
- can we find common grounds for the model selection?
- can more products report their uncertainties?
- can TD models reduce their uncertainty ?
- allocate more attention to regions or countries?
- including missing flows (e.g. trade)
- links with $CoCO_2$ project and city dimension

Thank you for your attention

For questions/comments please send an email to:

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