

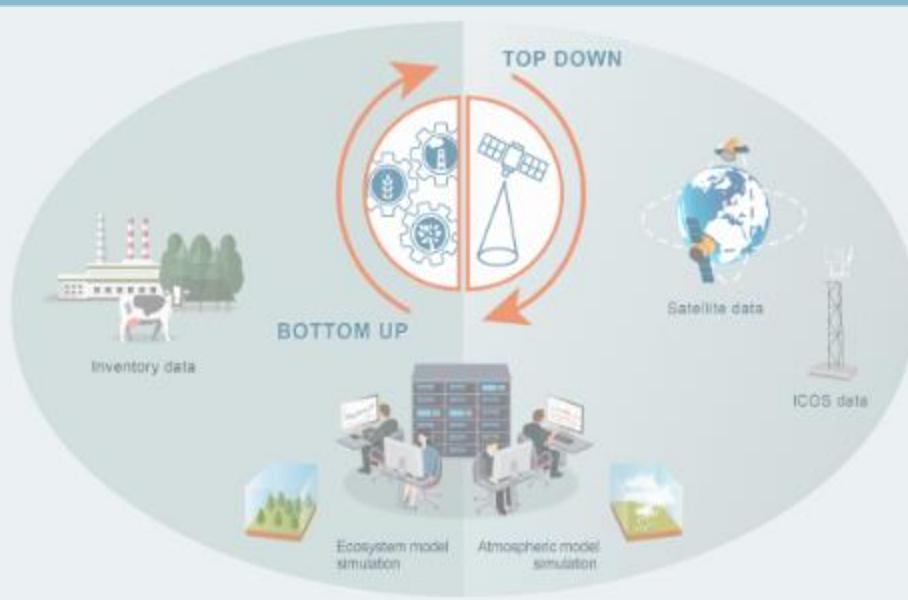


VERIFY WP2 Verification methods for CO₂ ff emissions

Why try to “verify” CO₂ ff?

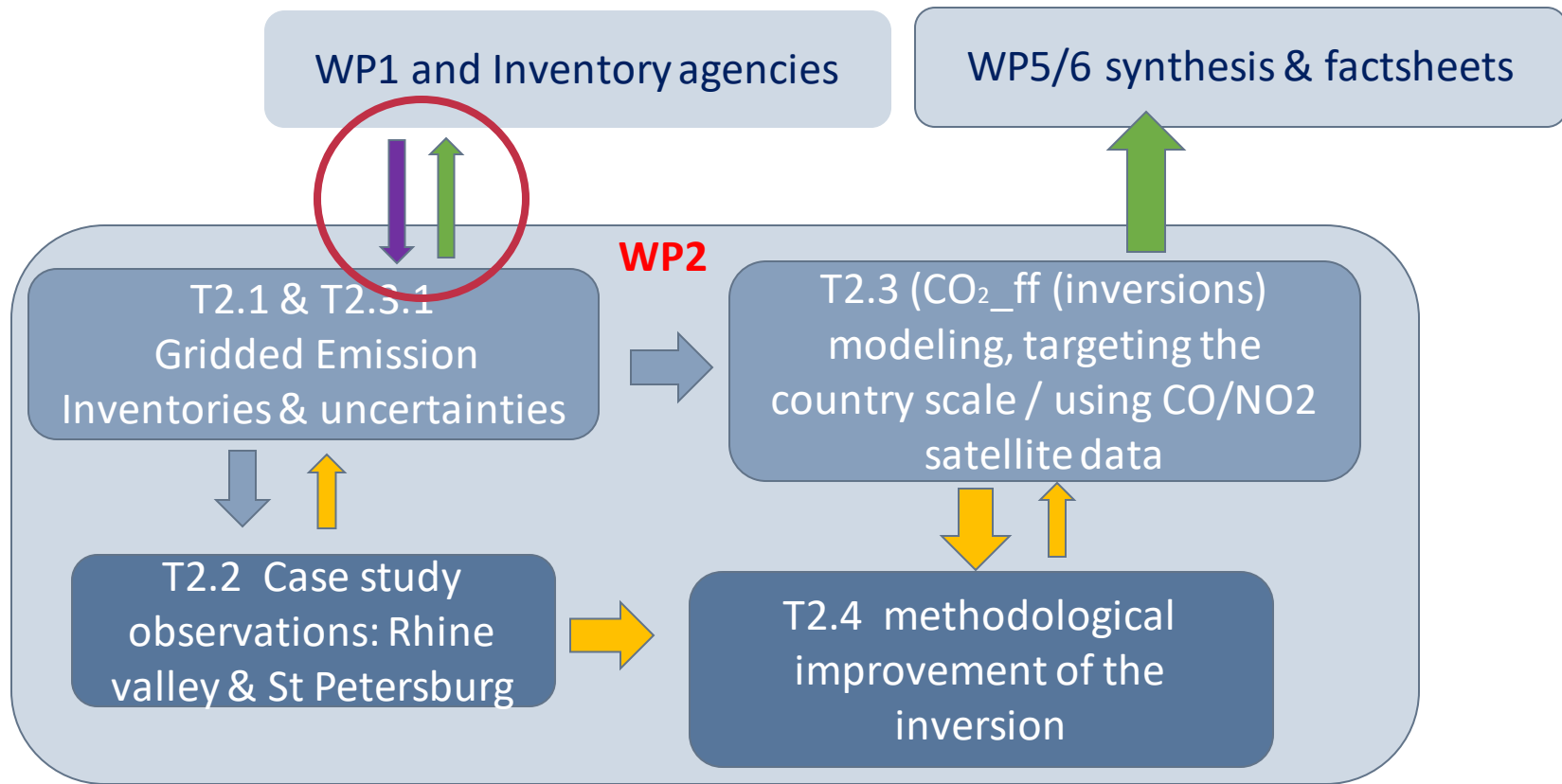
*Hugo Denier van der Gon & Paul Palmer
(on behalf of WP2 team)*

VERIFY WP1 networking meeting
November 10, 2020



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

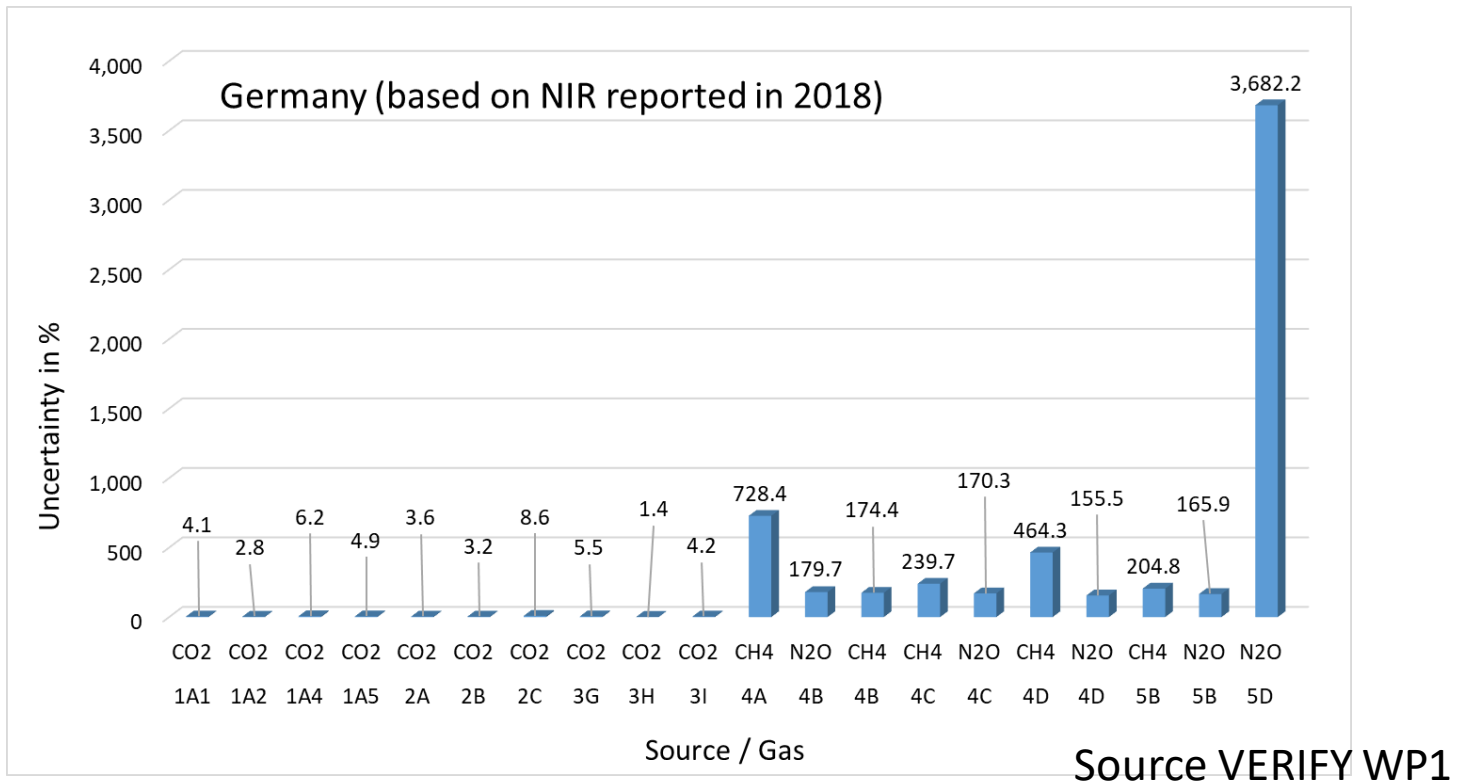
VERIFY WP2 Verification methods for CO₂_ff emissions – information flow chart



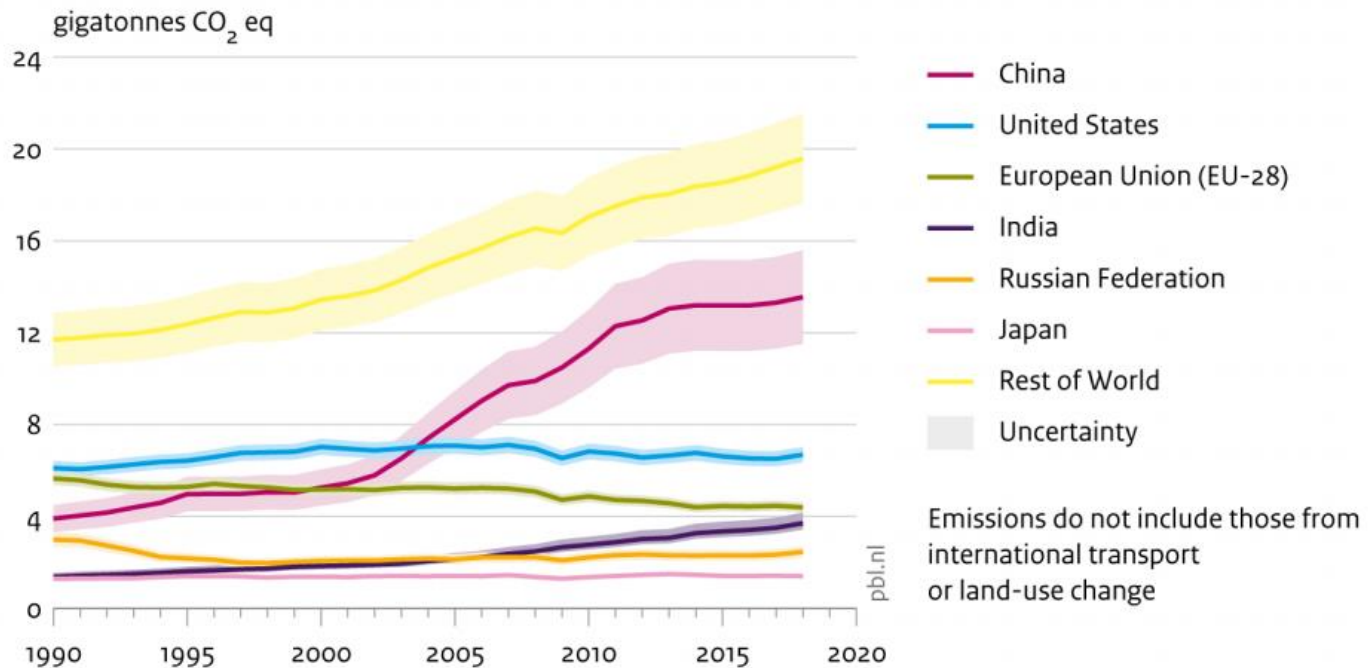
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CO₂ and inventory compilers

- Anthropogenic (fossil fuel) CO₂ is the best known and “easiest” pollutant
- The uncertainty in the EU at national level is small, order ~3-6%
- Is VERIFY WP2 going to contribute to improvement? Or even confirmation?



Climate Change (and CO₂) is a global problem



Source: EDGAR v5.0 FT2018; incl. savannah fires FAO; F-gas: EDGAR v4.2 FT2018

Source: Olivier and Peters (2020)

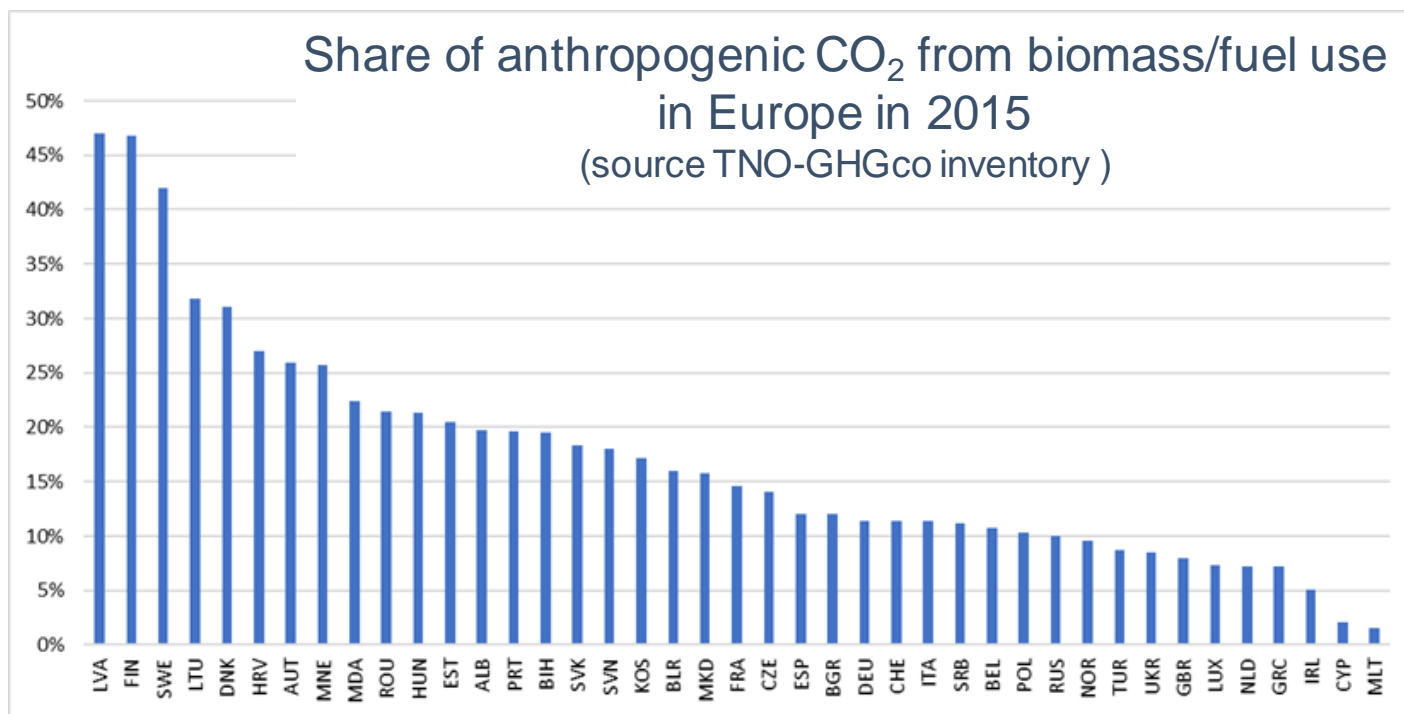
EU CO₂ emissions are important; The rest of the world is a lot more important

Focussing on “only” our own emission problem is simply a “no go”

- 🔴 Maturity of inventories varies widely; Critical uncertainties in CO₂ inventories exist
- 🔴 Important to work on methods that can confirm / verify / improve CO₂

CO₂ inventories: Complexity increases with time - i

1. In Europe already 12-15% of the anthropogenic CO₂ emission is from biofuel/biomass combustion; large variation between countries (see figure)
2. Biomass as a fuel is increasing – how short cycle is this?
<https://www.scientificamerican.com/article/congress-says-biomass-is-carbon-neutral-but-scientists-disagree/>



Inventory data on biomass and biofuels is more uncertain than fossil fuels!

CO₂ inventories complexity increases with time - ii

- Carbon Capture and Storage (CCS) might become important
- This will partly decouple CO₂ emission from the amount of fuel combusted.
- Estimation will become less reliable

*Norway has the world's largest test facility for CO₂ capture technology at Mongstad
Photo: MariusL, TU/ iStock.*



<https://norwegianscitechnews.com/2019/10/this-is-what-you-need-to-know-about-ccs-carbon-capture-and-storage/>

SO....Why work on independent verification of CO₂?

- ❗ **Current inventories may not be sufficient to monitor the effectiveness of climate policy**
 - 👉 Currently in some countries outside of Europe
 - 👉 In the future maybe even in Europe?
- ❗ Bottom-up (national) inventories with detailed source sector information are & will remain crucial to inform, negotiate and design action.
- ❗ Measurement-based verification will increase transparency, help building trust between parties and can confirm trends or mitigation

❗ **We need novel methods! This is work & research in progress!**

❗ **To apply these methods we need observations, emission inventories & models**

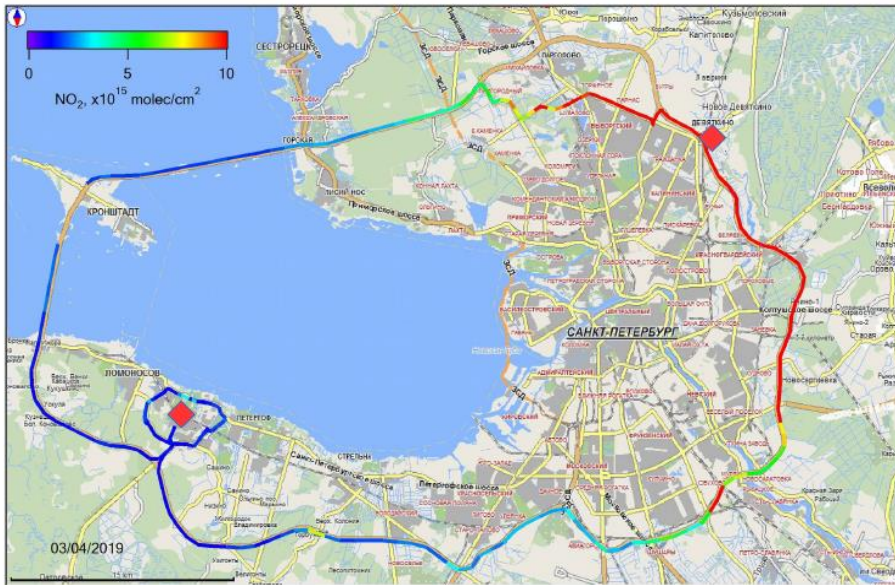


Example of novel method testing in VERIFY WP2

St Petersburg campaign (EMME)

- Russian VERIFY partners (St. Petersburg State University SPBU + Ural State University) supported by IUP Bremen and KIT.
- **April 2019: campaign for observing the St. Petersburg city emissions** using COCCON (Collaborative Carbon Column Observing Network) spectrometers (CO₂, CO) and other instrumentation (e.g. NO₂)

Ring roadway observations of NO₂ tropospheric column
- St. Petersburg NO₂ plume 03.04.2019
1A-3B



<https://doi.org/10.5194/amt-2020-87>
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Emission Monitoring Mobile Experiment (EMME): an overview and first results of the St. Petersburg megacity campaign-2019

Maria V. Makarova¹, Carlos Alberti², Dmitry V. Ionov¹, Frank Hase², Stefani C. Foka¹, Thomas Blumenstock², Thorsten Warneke³, Yana A. Virolainen¹, Vladimir S. Kostsov¹, Matthias Frey⁴, Anatoly V. Poberovskii¹, Yuri M. Timofeyev¹, Nina N. Paramonova⁶, Kristina A. Volkova¹, Nikita A. Zaitsev¹, Egor Y. Biryukov¹, Sergey I. Osipov¹, Boris K. Makarov⁵, Alexander V. Polyakov¹, Viktor M. Ivakhov⁶, Hamud Kh. Imhasin¹, Eugene F. Mikhailov¹

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<https://www.atmos-meas-tech-discuss.net/amt-2020-87/>

Figure courtesy of SPBU

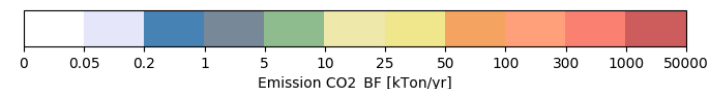
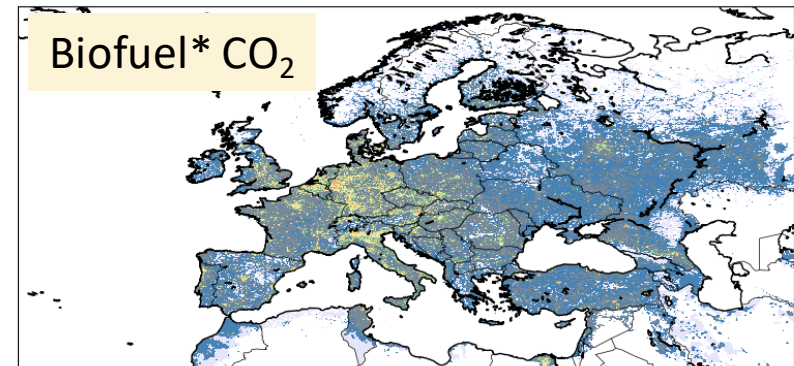
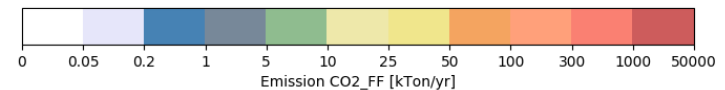
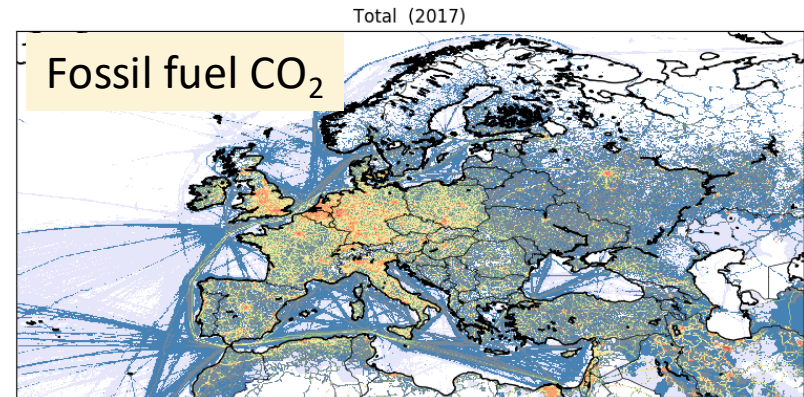
Some methods suitable for city / sub-national scale – connection to national scale is not trivial

How is VERIFY WP2 using NIR data?

VERIFY TNO_GHG_co v2 Regional emissions 2005-2017

- 🚫 Uses UNFCCC and EMEP reported national data from national agencies as starting point
- 🚫 Uses E-PRTR point source data
- 🚫 (some) Key features:
 - 👉 Split CO₂ and CO from fossil fuels / biofuels
 - 👉 6x6km, co-locating GHG and co-emitted species (CO, NO_x)
 - 👉 Temporal emission and emission height profiles
- 🚫 Up-to-date inventories → predict t-1, t-2
- 🚫 Note: we also use the uncertainty data and activity data provided in the CRFs

When you see results using the VERIFY / TNO inventory – remember these are in-line / based on national reported data!



* Biofuel here = liquid & solid anthropogenic combustion (excl forest fires)

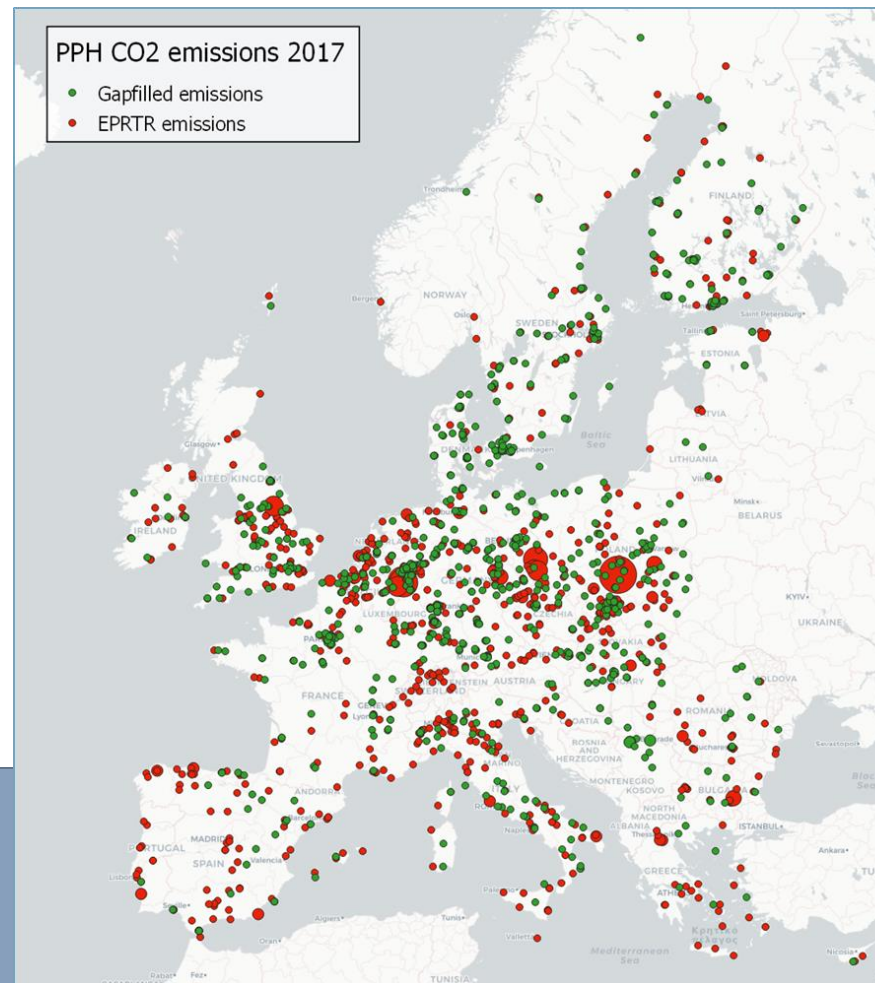


How is VERIFY WP2 using national reported inventory data?

TNO_GHG_co v2 Regional emissions 2005-2017

- Uses UNFCCC and EMEP reported national data from national agencies as starting point
- Uses E-PRTR point source data
- (some) Key features:
 - Split CO₂ and CO from fossil fuels / biofuels
 - Point source at exact location; gap filling to improve the dataset
 - Consistent gridding, co-locating GHG and co-emitted species (CO, NO_x); gap filling to improve the dataset
 - Temporal emission and emission height profiles

When you see results using the VERIFY / TNO inventory – remember these are in-line / based on national reported data!



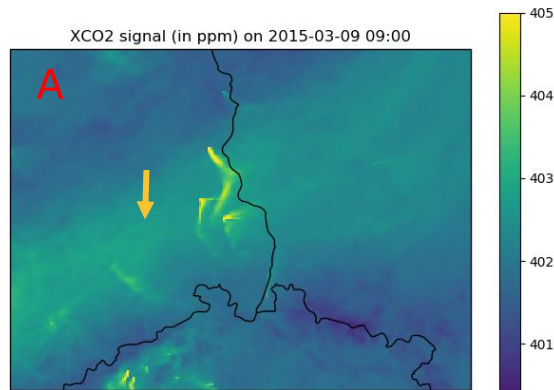


How important is a good representation of emissions?

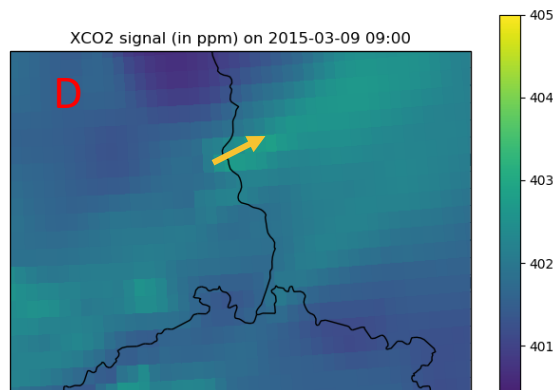
Regional nature runs by CHE project:

Impact of model resolution and representation of emissions on XCO₂

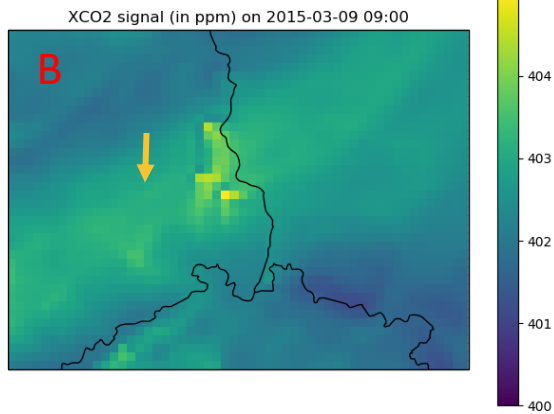
COSMO-GHG 1km, TNO emissions



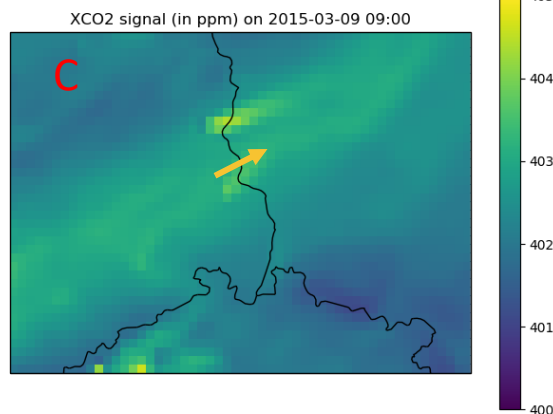
Tier-1 (CAMS), 9km, EDGAR emissions



COSMO-GHG 5km, TNO emissions



COSMO-GHG 5km, EDGAR emissions



- Emission plumes strongly affected by vertical placement of emissions due to wind shear
- Significant differences between inventories for point sources

Figures by J.-M. Haussaire, D. Brunner (Empa) and A. Agusti-Panareda (ECMWF)

To use observations we will need to push our a-priori data & modelling capacity to the max.





Connection of atmospheric CO₂ inversion results to needs of inventory agencies?

This will be a journey – with stops along the way....

- ☛ CO₂ inversion at (sub)country scale is really research in progress – some (more) patience is needed....
- ☛ Inventory is build up from detailed source sectors – this cannot be done from the atmosphere - *so we need to translate for each other*
- ☛ To come closer we need co-emitted species and close-to-present inventories (t-1) (observations cannot go back in time)
- ☛ In the atmosphere all combustion CO₂ is important; also from biofuels/ biomass
- ☛ Next speaker will give illustration of approach and developments



To discuss with inventory agencies?

The NIRs are a great source of information – keep up the good work!

You may have wishes? Here some points (not intended as complaints!) from our side;

1. Spatial distribution & point sources are critical for VERIFY tools
2. Biomass and biofuel CO₂ is becoming increasingly important – where and when?
3. E-PRTR / ETS data not always right... who checks locations? Moreover, National inventory is sometimes not related to the LPS and/or EPRTR reporting?
4. GHG and air pollutants are often not consistently reported together + Reporting thresholds and/or gaps reduce the EPRTR data quality! – we find CO₂ emissions w/o NO_x or CO; and vice versa...
5. Underlying Tier 2/3 emission calculations very specific local/regional data may be used with specific details on processes – this could be highly valuable but difficult / unclear how to obtain.
6. Despite the format, differences in how the CRFs by different countries are filled create difficulties; Reporting Year to Reporting year changes in how the CRF is filled can be substantial: Having one big data file at EU level with max. detail, but consistent would be great.
7. Reporting in CO₂ eq sometimes leads to errors

Possibly dig into 1-3 country jointly with WP1 as a case?



Thank you for your attention.



10/11/2020



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