



Atmosphere Monitoring

CAMS emissions

Perspectives on official reported emission data

Jeroen Kuenen & the CAMS2_61 team



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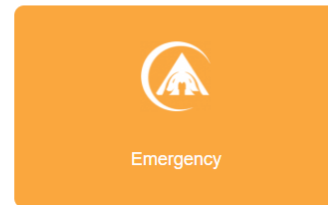
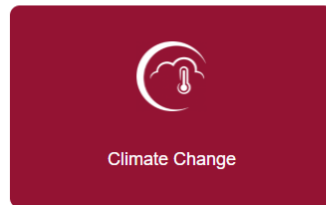
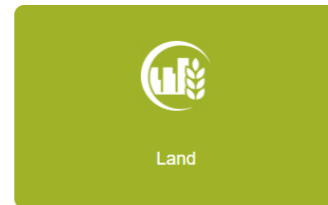
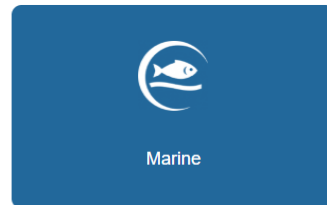
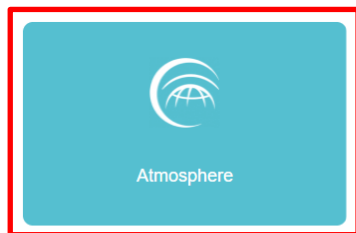




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The EU Copernicus Programme

- **Copernicus** is the Earth observation component of the European Union's Space programme, looking at our planet and its environment to benefit all European citizens. It offers information services that draw from **satellite Earth Observation and in-situ (non-space) data**.
- CAMS-2.0 started in 2021
- Copernicus makes available vast amounts of data from satellites and ground-based, airborne, and seaborne measurement systems to help improve European citizens' quality of life and beyond.
- All data services provided are **free** and **openly** accessible to users.



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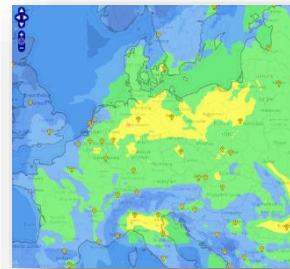
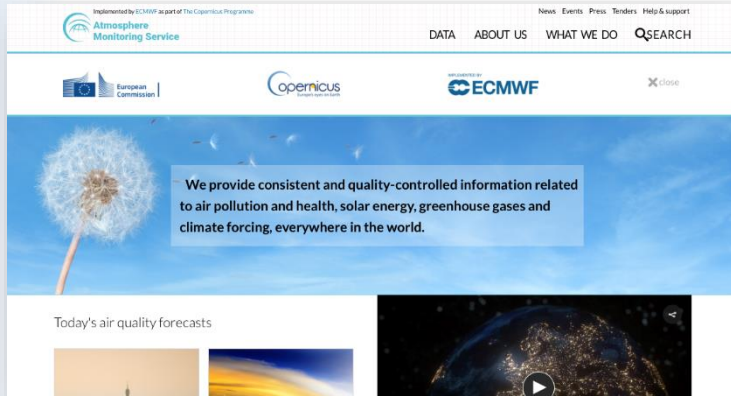


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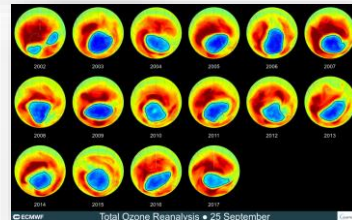
Copernicus Atmosphere Service

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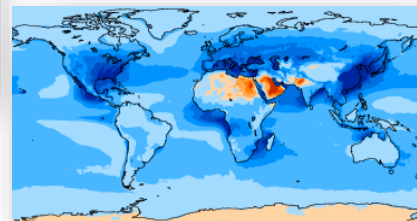


European Air Quality and products in support of policy users

Ozone layer



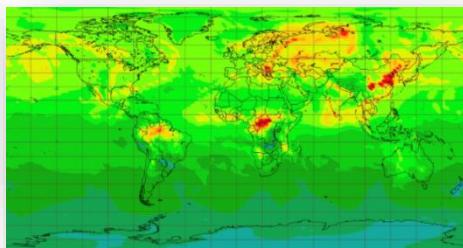
Climate forcings



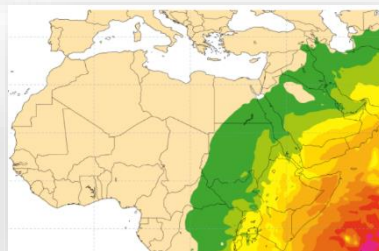
Europe's eyes on Earth



Bottom-up emissions and surface fluxes of greenhouse gases



Global analyses, forecasts and reanalyses (2003-...)



Solar radiation and UV index



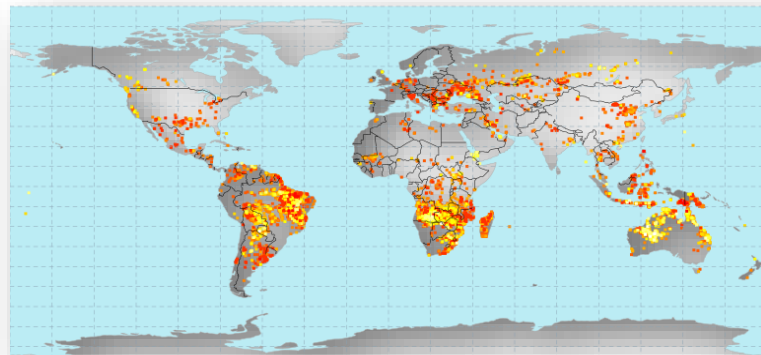
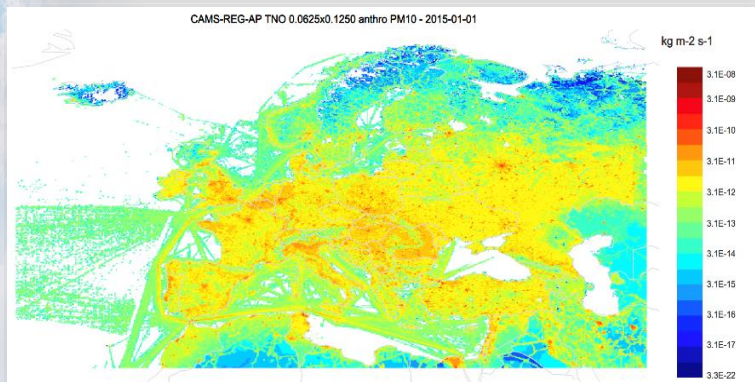
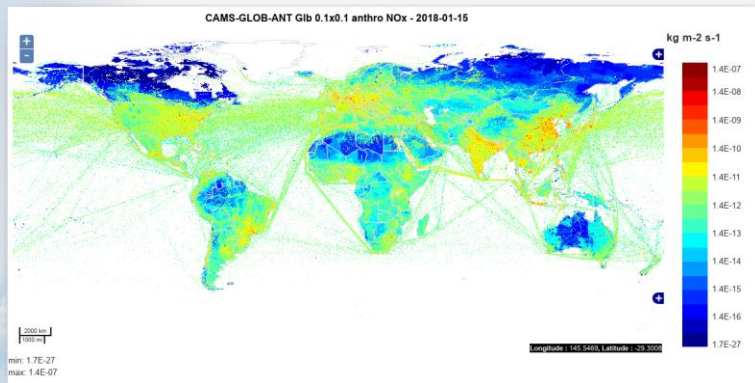
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From V-H Peuch, ECMWF



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CAMS Emission Service



- Global anthropogenic emissions
- Regional anthropogenic emissions
- Shipping emissions
- Natural emissions



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Why CAMS European emissions?

- Modellers need all anthropogenic emissions for a given domain
 - For all sectors, pollutants & countries (also beyond EU!)
 - Gridded data
 - Consistency
- Reported data do not always meet the needs
 - Countries reporting incomplete or not at all
 - Gridded data only once every 4 years, and not all countries report
 - Consistency in pollutants (condensables)
 - Additional relevant information is missing (composition, temporal disaggregation, injection height)
- Need for a consistent and complete annual emission inventory to provide a good input to air quality modelling studies



CAMS emissions – what is produced?

Core work
European emissions for
latest reporting year

Ref2 inventory
Science-based
alternative to reported

Recent years
Extrapolation to
almost now

- Produced annually in Fall with for latest available year (t-2), based on official submissions earlier that year
- Based on reported emissions earlier in the same year
- Follows methodology from [Kuenen et al. \(2022\)](#)

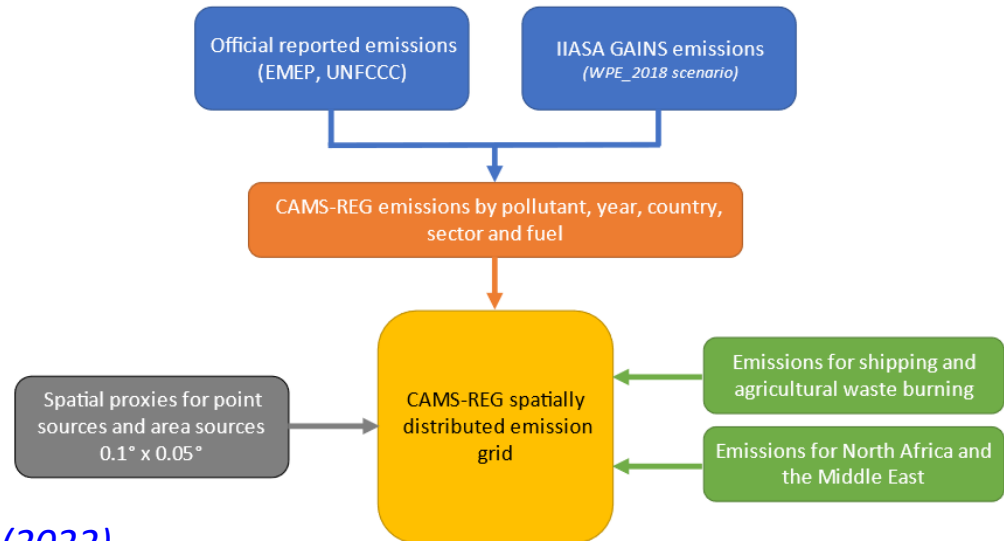
- PM emissions from GNFR C replaced with own estimate (“Ref2”) because of inconsistency wrt condensables
- Details see <https://pub.norden.org/temanord2022-540/>
- Currently used in CAMS operational production

- Develop an extrapolation approach for emissions to the 2 most recent years (t-1, t)
- Users (modellers) want to model air quality for the current situation
- To be used in CAMS operational production later this year



Summary of methodology

- Make use as much as possible of official reported data (“accepted” in policy)
 - Not the gridded data, but only the Annex I inventory (“NFR tables”)
- Gapfill with alternative data sources where necessary
- Apply a consistent European spatial distribution methodology

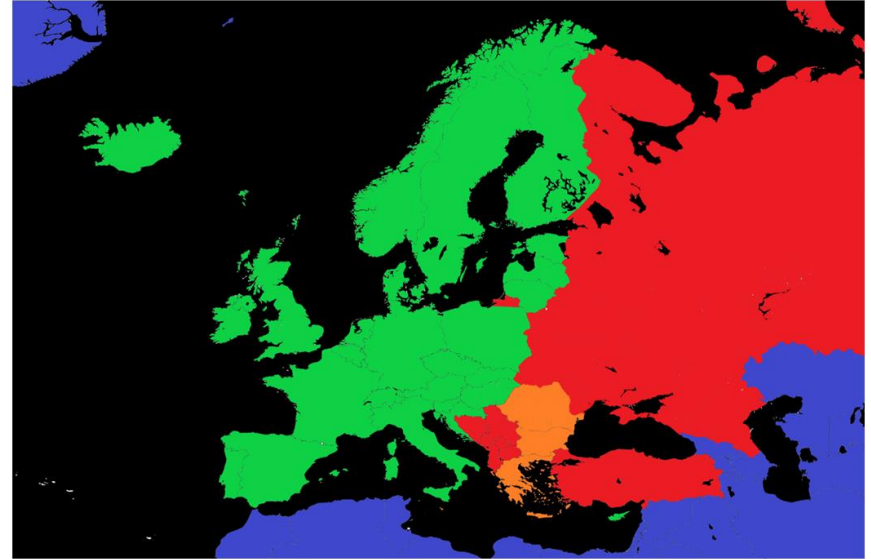


For details, see [Kuenen et al. \(2022\)](#)



So how much reported data are used?

- **Green** countries: reported data used as such
- **Orange** countries: reported data used with corrections
- **Red** countries: reported data not available/not used
- Emissions from rest of Europe are very important
 - Cooperation in UNECE context





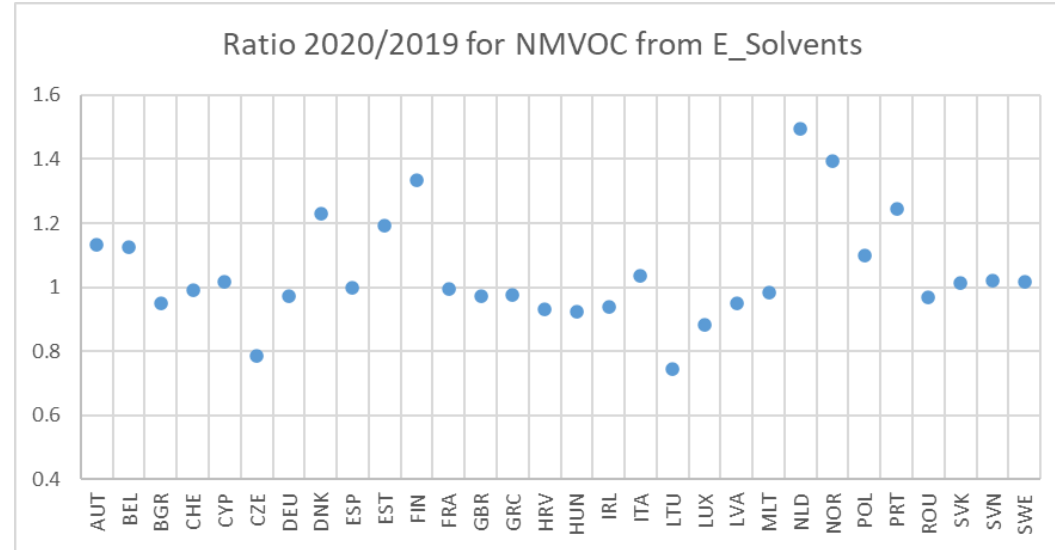
Where reported data are not used

- In some cases, reported data are not directly taken up
- Shipping (domestic, int'l inland waterways & maritime)
 - Use FMI STEAM model results consistently over whole of Europe
- Field burning of agricultural wastes
 - Replaced with consistent estimates based on satellite observations
- Agricultural soil NO_x emissions (NFR 3D)
 - Excluded since most models calculate this themselves
- Road transport
 - Correction made for Luxembourg (*fuel sold vs. used*)
- NMVOC from hand sanitizer use
 - Coming up (next slide)



- Appear to be included in some country inventories, but ignored in most of them
- For the CAMS inventory, one consistent estimate made for Europe and distributed over countries
- This source adds over 400 kton (~4%) to total NMVOC emissions (EU27+UK) in 2020

Reported inventories (2022 submission)





Spatial distribution

- Spatial distribution is key for application in dispersion models
- Gridded data from countries are in principle great but...
 - Only every 4 years, and not all countries actually submit
 - When available, quality varies: good to poor (*NECD reviews 2020/2021*)
 - Assessment of gridded data reporting is tricky... how do you judge?
- Alternative: apply uniform spatial distribution across Europe
 - Resolution $0.05^{\circ} \times 0.1^{\circ}$ (lat-lon)
 - Use of proxy variables available consistently over Europe
 - Use point source database (primarily E-PRTR) for large point sources

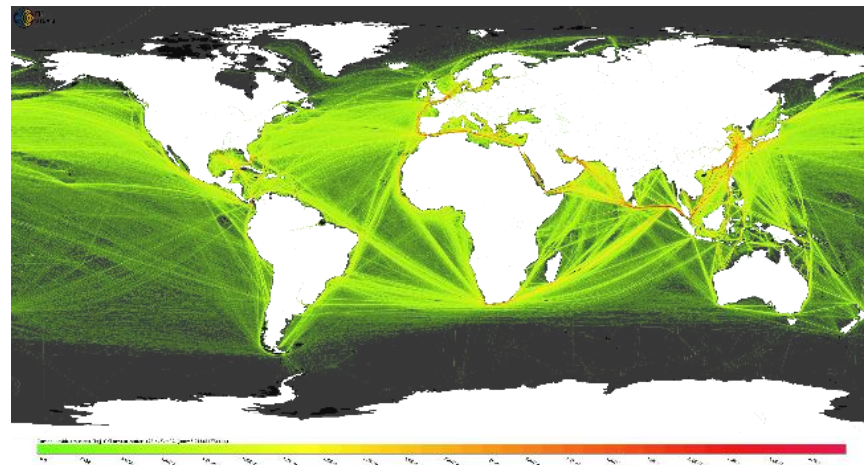
For details, see [Kuenen et al. \(2022\)](#)



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Shipping emissions

- Ship movements based on Automatic Identification Signals (AIS)
- Detailed shipping model (STEAM) including technical specs of different ship types and associated emission factors
- Global coverage, daily resolution
- Ongoing developments including impacts of weather and sea conditions (waves, currents, etc.)



[Johansson et al. 2017](#)
[Jalkanen et al. 2016](#)



FMI

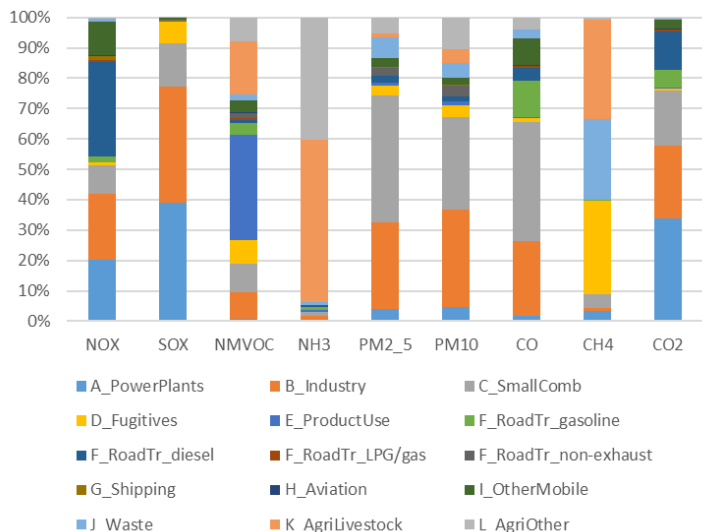
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CAMS-REG version 6.1

Years: 2019 & 2020

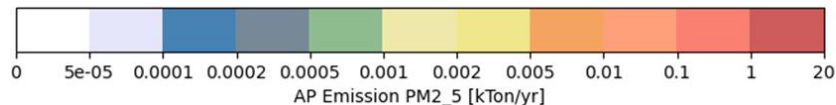
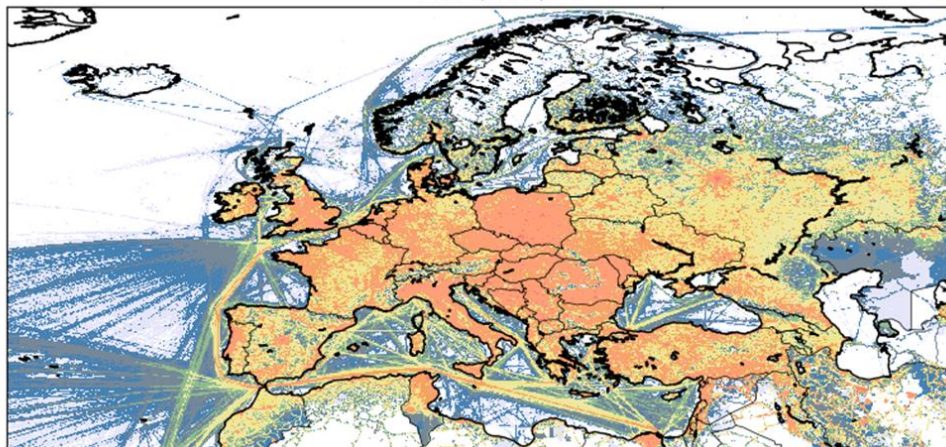
Emission distribution over sectors (2020)



Change 2020 compared to 2019 per region (%)

	NOX	SOX	NMVOC	NH3	PM2.5
EU+_North	-9%	-16%	1%	1%	-5%
EU+_WestCentral	-14%	-10%	-2%	-4%	-8%
EU+_East	-8%	-7%	-2%	0%	-1%
EU+_South	-16%	-17%	-2%	3%	-4%
NON_EU	-3%	-12%	-2%	1%	0%
Average	-9%	-12%	-2%	0%	-2%

Total (2019)

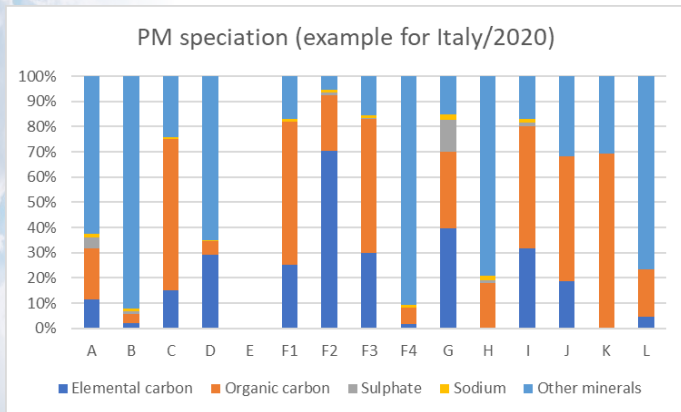




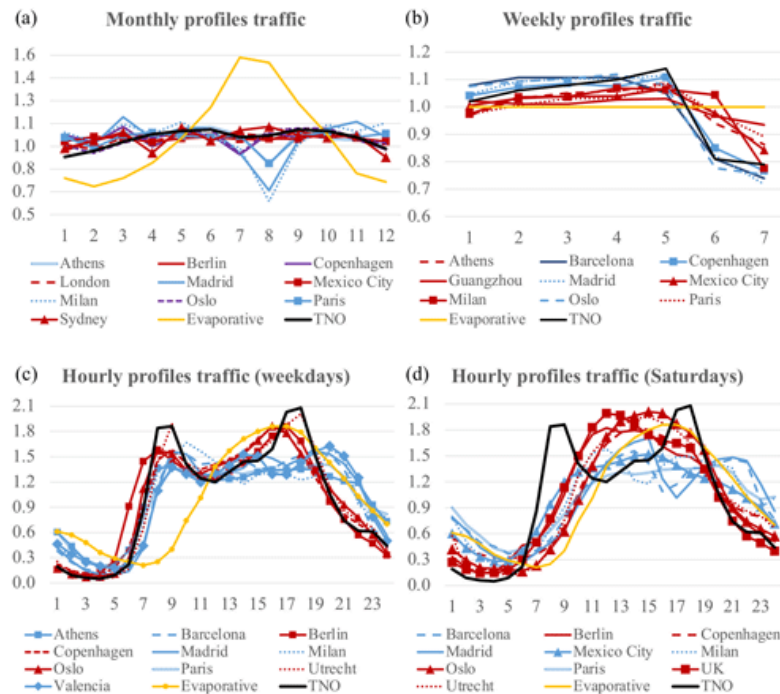
Application in models

- More needed than just spatially disaggregated emissions
 - Emission height information
 - Speciation for NMVOC
- All provided by CAMS-REG service

Speciation for PM ([Kuenen et al. 2022](#))



Temporal emission profiles ([Guevara et al. 2021](#))





Recap and conclusions

- Air quality modelling at European scale requires consistent, complete and reliable emissions
- Reported emissions ideally fit these needs
 - In practice, some issues with reporting frequencies and quality/incompleteness limit the applicability, especially for gridded data
- CAMS-REG provides annual emission grids ($0.05^\circ \times 0.1^\circ$)
 - Use reported emissions but make specific adjustments
 - Gapfill for missing counties (or in case of poor quality)
 - Include additional information that modellers need
 - Estimate emissions for the most recent year(s)
- All CAMS emissions are publicly available: <https://eccad.aeris-data.fr/>



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CAMS2_61 overview

Any questions?

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