Abschätzung der Emissionen infolge Verbrennung fossiler Brennstoffe im Jahr 2021 aus atmosphärischen und anderen Beobachtungen mit Hilfe eines Datenassimilationssystems für den Kohlenstoffkreislauf, das fossile Brennstoffe einschließt

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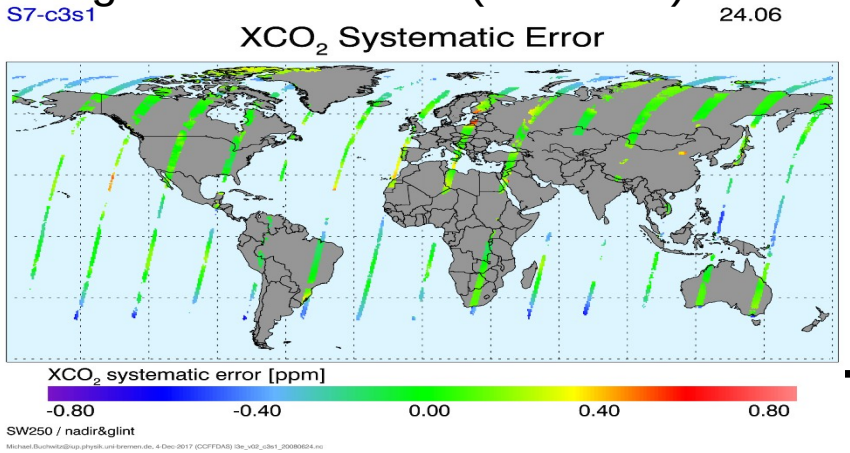
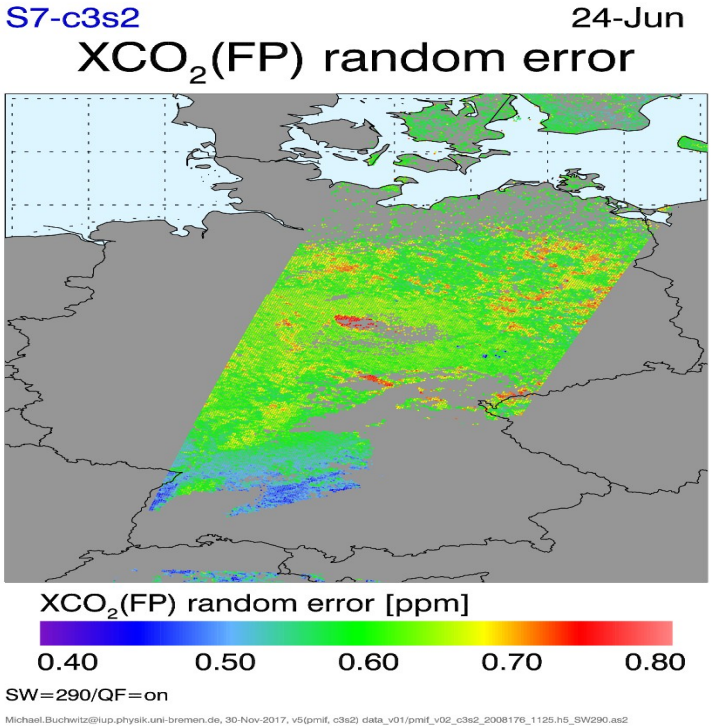
4 IUP, Bremen, Germany
5 BSC, Barcelona, Spain

Funding: ESA + H2020 (CHE, CoCO2)

CO2 Monitoring Mission (CO2M)

- Planned by Copernicus Programme
- Fossil fuel carbon emissions
- Multi-Satellite Constellation
- Imaging Capability
- 2 km x 2 km grid
- wide swath
- XCO2
- NO2
- Multi-Angular Polarimeter (Aerosols)

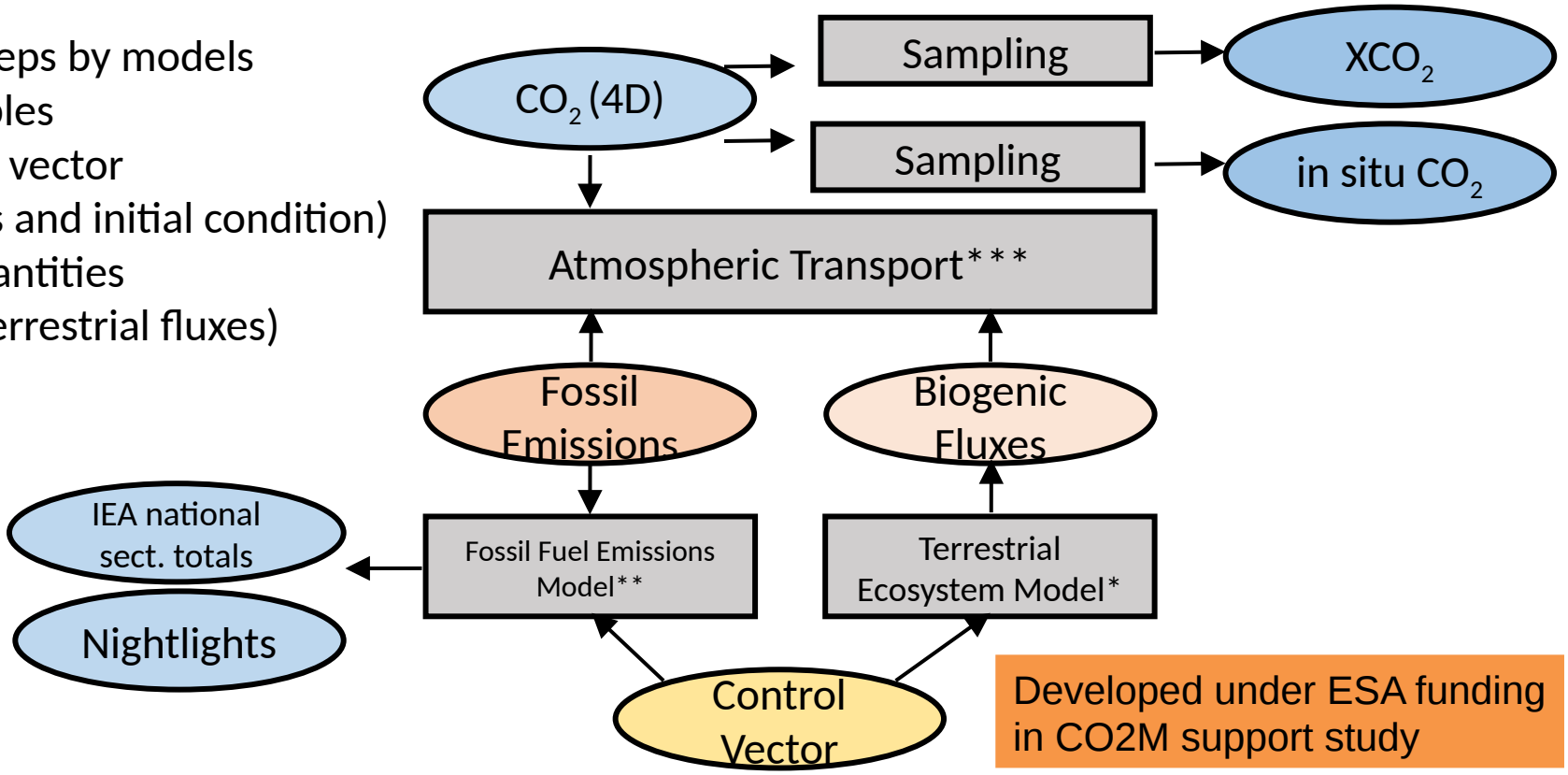




CO2M uncertainties:
Buchwitz et al. (2013)

(global scale) Carbon Cycle Fossil Fuel Assimilation System

Boxes: calculation steps by models
Blue ovals: observables
Orange oval: control vector
(model parameters and initial condition)
Red ovals: target quantities
(fossil emissions, terrestrial fluxes)



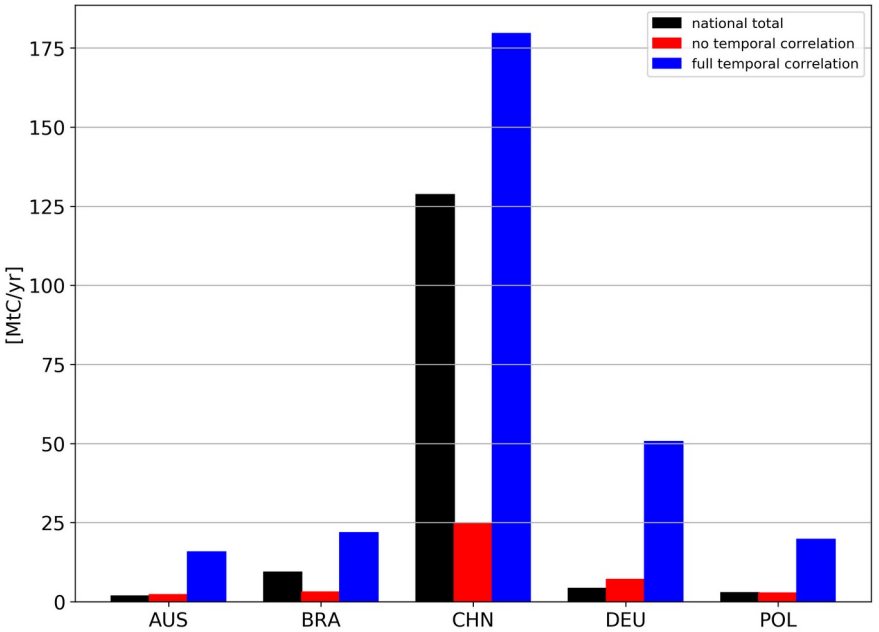
Developed under ESA funding in CO2M support study

Kaminski et al., ERL, 2021. Components: *Kaminski et al. (2017), **Asefi-N. et al. (2014), *** TM3-Heimann&Koerner (2003)

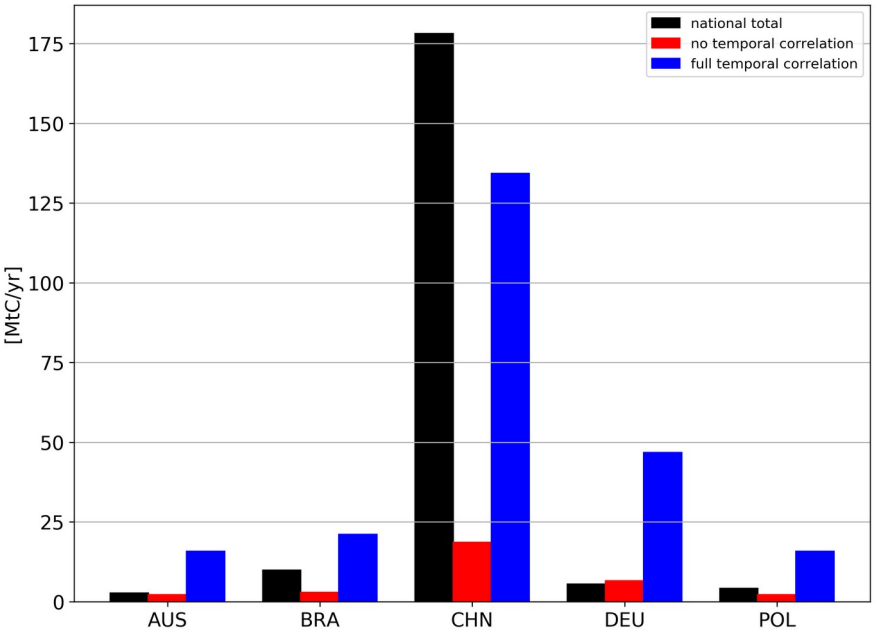
National scale sectoral emissions
IEA (black) vs posterior CCFFDAS uncertainties

black: national total emissions
blue/red: CCFFDAS national total emission uncertainties

1st week of June
XCO2 (1 CO2M satellite) + nightlights



Non-Energy Generation Sectors



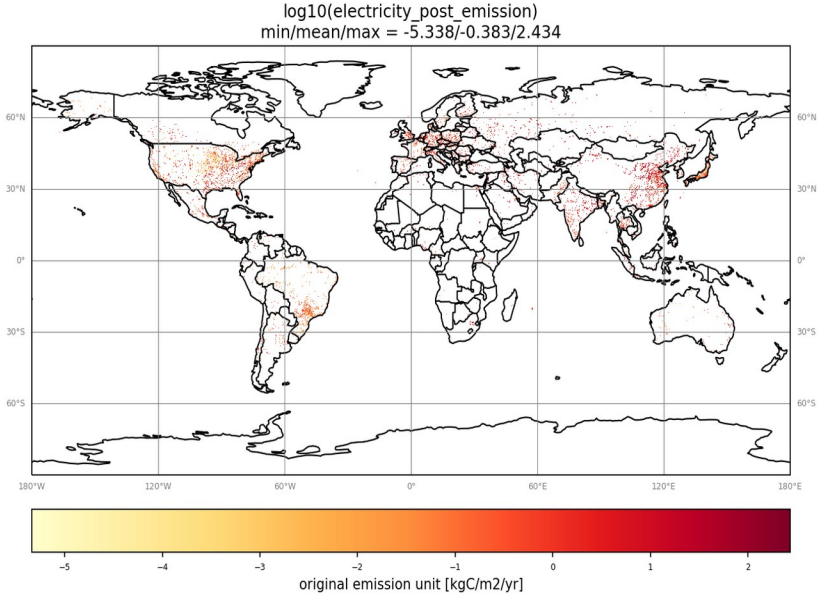
All sectors

Kaminski et al., ERL, 2022

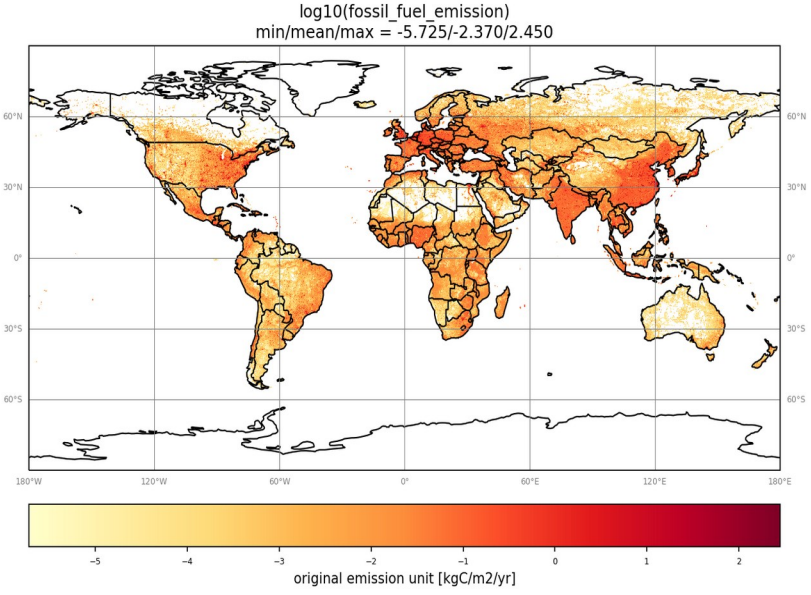
CCFFDAS Contribution to first global stocktake

- Contribution submitted via H2020 project CoCO2
- Data Streams used for preliminary CCFFDAS estimate of 2021 fossil emissions:
  - 2018 sectoral national emission totals from the International Energy Agency (IEA)
  - Night-light intensities observed by satellites (Elvidge et al., 2021)
  - Atmospheric CO_2 concentrations from measurements provided by the Greenhouse Gases Observing Satellites 1 and 2 and from the Orbiting Carbon Observatory 2 (Reuter et al., 2013)
  - Locations of and emissions from individual power plants for the year 2018 derived within CoCO2
  - Fraction of Absorbed Photosynthetically Active Radiation by plants derived by the Joint Research Centre-Two-stream Inversion Package from satellites (Pinty et al., 2011)
  - A map of population density (Sims et al., 2022)
  - Meteorological data from the fifth generation of ECMWF atmospheric reanalyses of the global climate (Hersbach et al.,2020)
- Technically: Gradient-based minimisation of cost-function enabled via automatic differentiation (Hascoët & Pasqual, 2013) of modelling chain.

CCFFDAS Posterior Fossil Fuel emissions



Electricity generation 2021

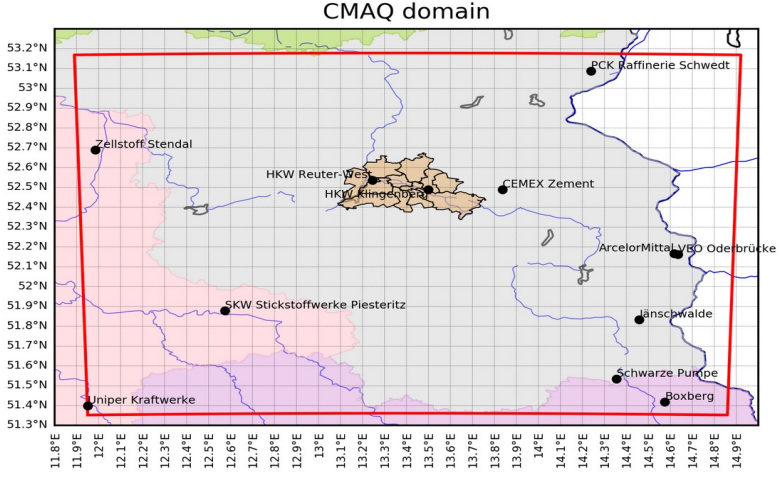


Total 2021

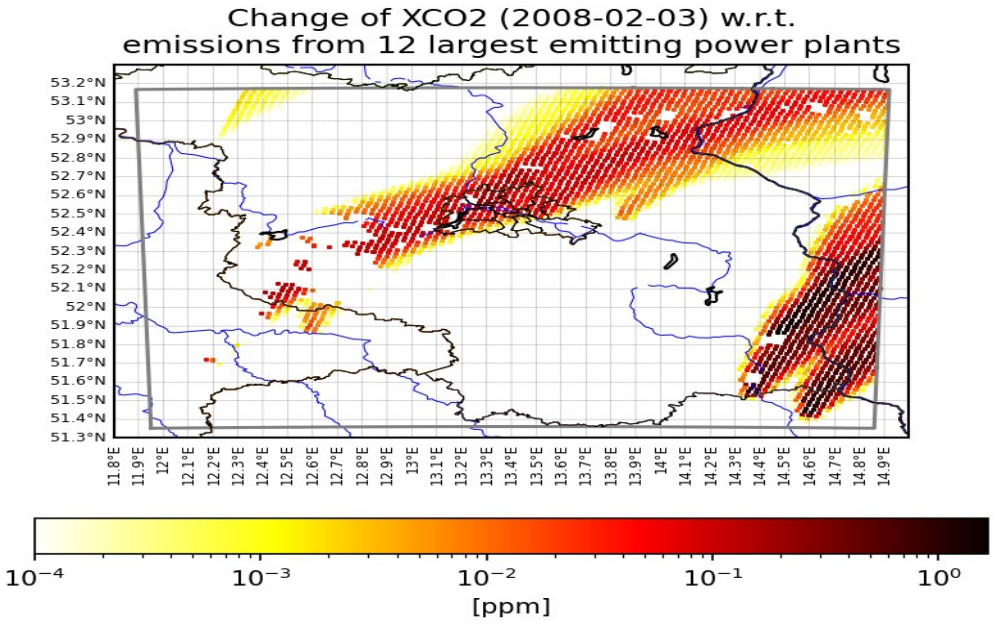
(local) CCFFDAS: High Resolution over Berlin

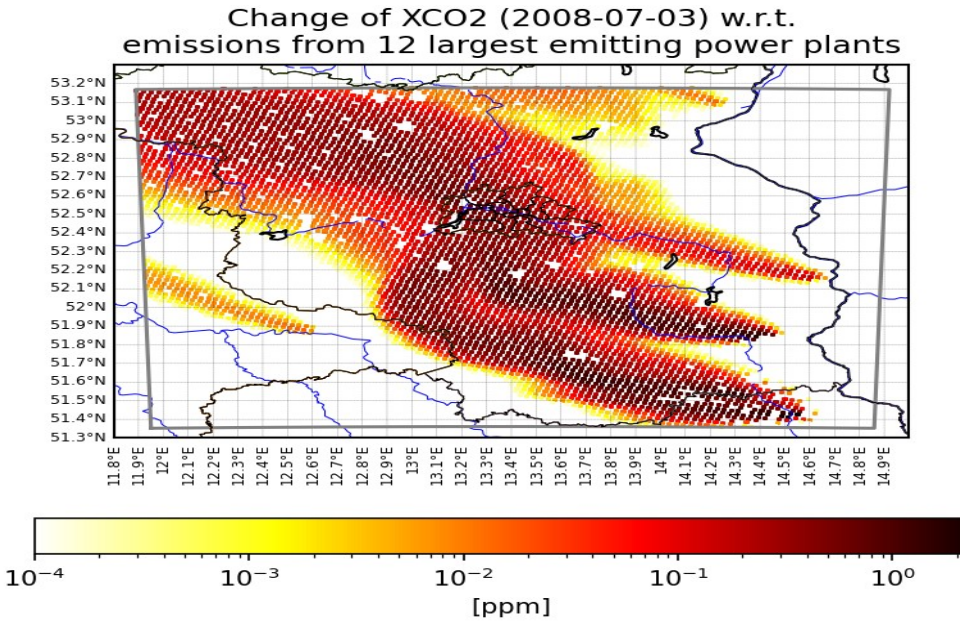
Modelling System:

- CMAQ in 2 km x 2 km resolution
- 200 km area around Berlin
- Use simulated CO2M images
- Assess accuracy requirement for XCO2 alone
- And in conjunction with NO2
- Assess added value of a multi-angular polarimeter (MAP)
- Simulating 24 hour period before overpass



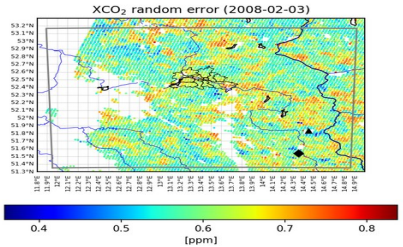
Plumes from Power Plants





One Study Period in Winter (left) and one in Summer (right)

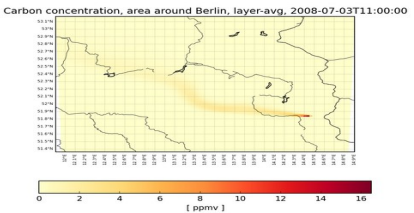
Modelling Chain



CO2M XCO_2

CO2M NO_2

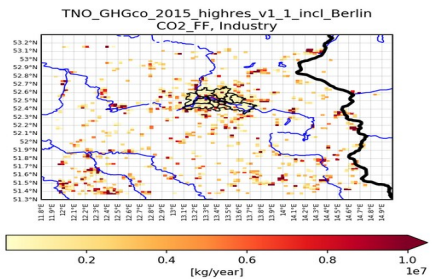
CO2M Sampling



XCO_2 + NO_2

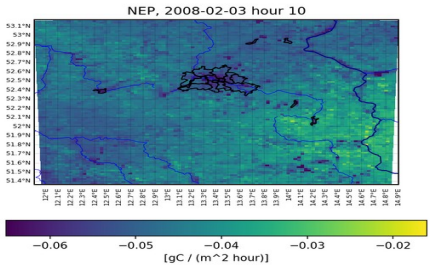
Boundary CO_2 + NO_2

CMAQ: Atmospheric Transport (2km x 2km) + vertical XCO2 averaging

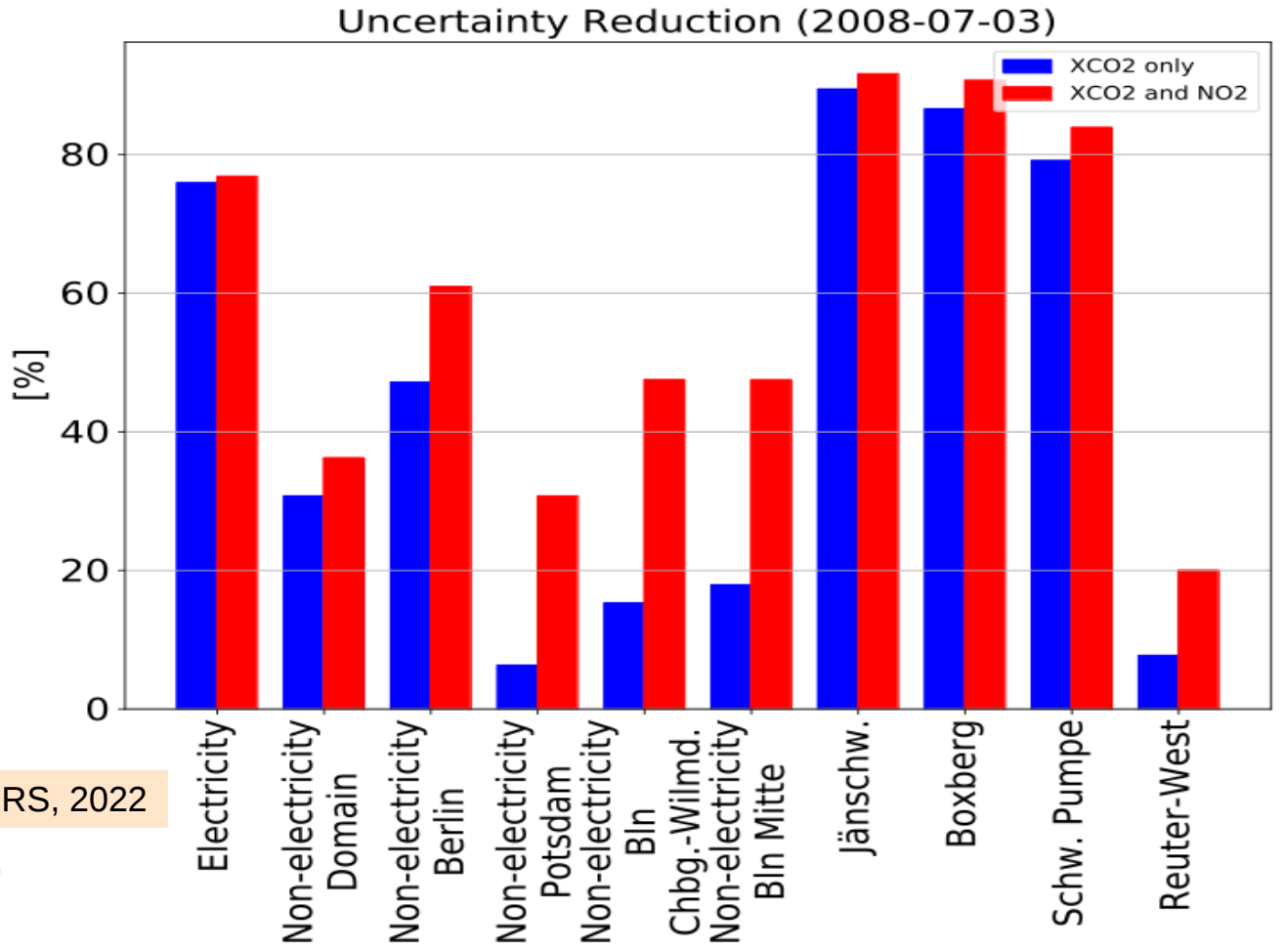


Fossil Emissions/Factors

Biogenic Fluxes



CO2M assessment



Kaminski et al., Front. RS, 2022

Summary and Conclusions

- Carbon Cycle Fossil Fuel Data Assimilation System (CCFFDAS) combines top-down and bottom up approaches
- Can integrate a range of atmospheric and terrestrial data streams into a consistent picture
- Is (per construction) capable of direct attribution at sectoral level
- Can be operated at local and global scales
- Provided contribution to first GST
- Working horses in Horizon Europe Projects CORSO and AVENGERS

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