Performance of upcoming CO2 monitoring satellites in the new high-resolution inverse model CTDAS-WRF

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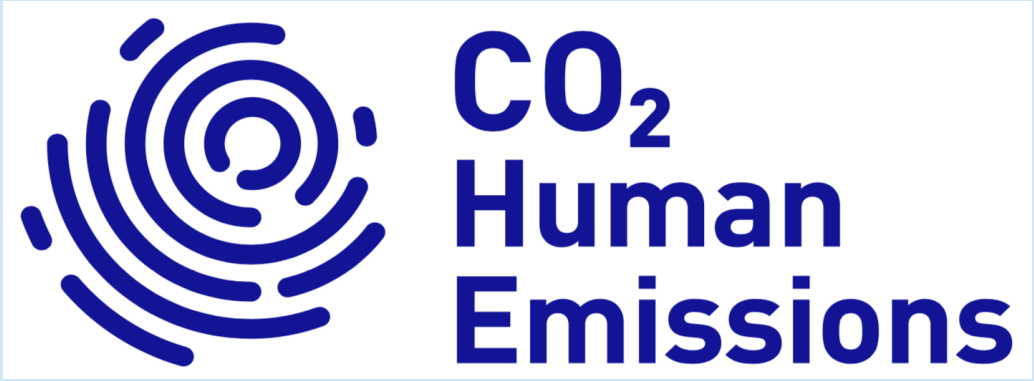
Anthropogenic GHG emission monitoring

- Active EU H2020 projects for advancing our capability to monitor anthropogenic CO2 emissions from space:



- Constellation of ~3 satellites (“CO2M”) (global daily coverage)
- che-project.eu

- Fleet of about 20~30 nano satellites (global daily coverage)
- scarbo-h2020.eu

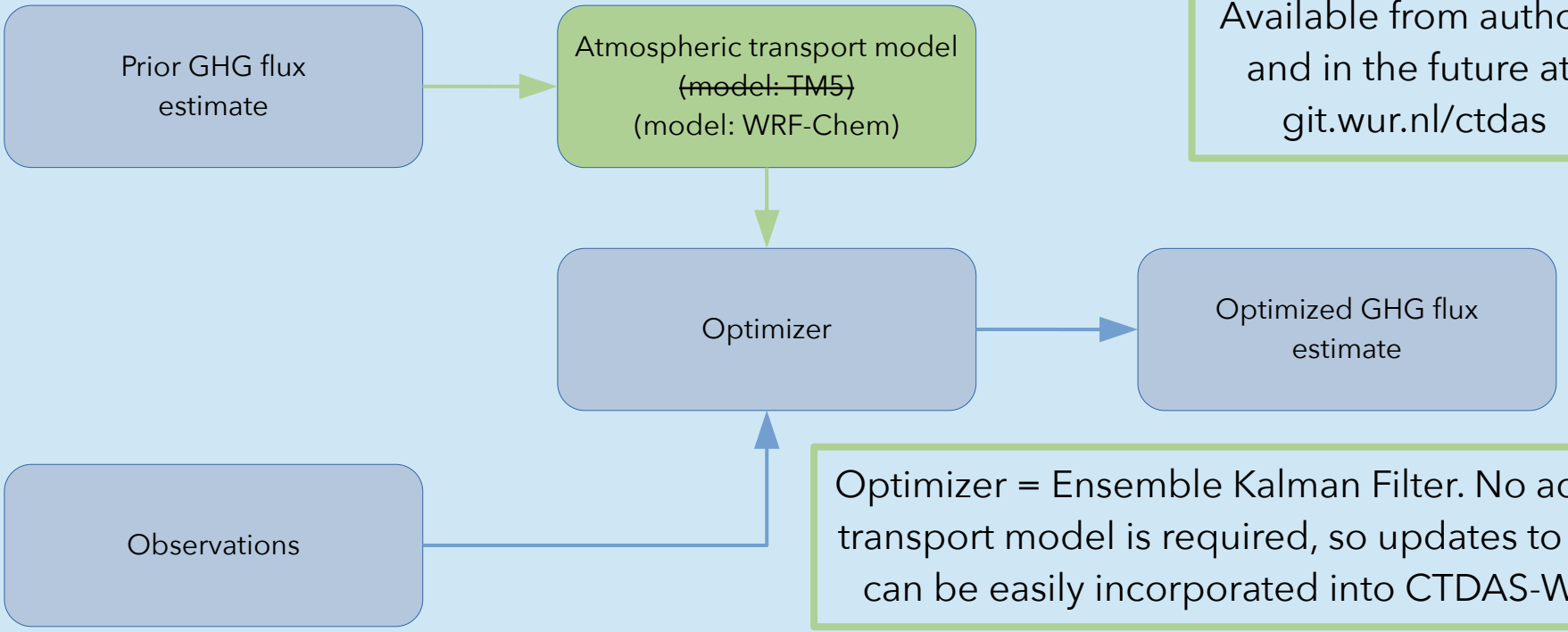
On WRF-CHEM as GHG transport model

- WRF has a large active user base
- Ongoing development
- Domain nesting allows simulating transport at resolutions down to LES scale
- WRF-Chem allows simulating atmospheric (trace gas) transport and chemistry
- WRF-GHG = greenhouse gas transport module[1]

1: Beck, V., et al.: The WRF Greenhouse Gas Model (WRF-GHG) Technical Report, [online] Available from: https://www.bgc-jena.mpg.de/bgc-systems/pmwiki2/uploads/Download/Wrf-ghg/WRF-GHG_Techn_Report.pdf, 2011.

New inverse model: CTDAS-WRF

- Flowchart of inverse model ~~CTDAS~~[2] CTDAS-WRF



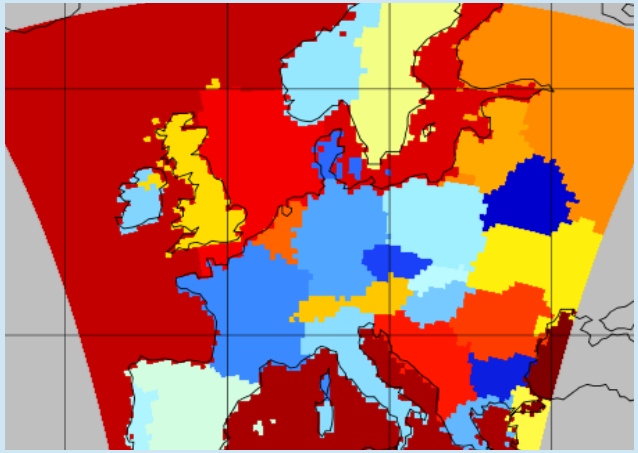
Available from authors and in the future at: git.wur.nl/ctdas

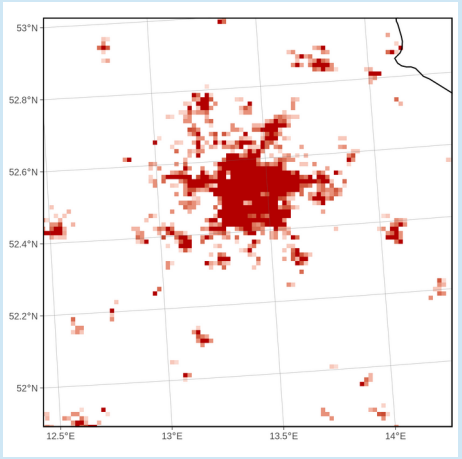
Optimizer = Ensemble Kalman Filter. No adjoint transport model is required, so updates to WRF can be easily incorporated into CTDAS-WRF.

2: van der Laan-Luijkx, I. T., et al.: The CarbonTracker Data Assimilation Shell (CTDAS) v1.0: Implementation and global carbon balance 2001-2015, Geosci. Model Dev., 10(7), 2785–2800, doi:10.5194/gmd-10-2785-2017, 2017.

CTDAS-WRF: current capabilities

- Optimizes passive tracer fluxes based on total column observations
- Applications: continental scales down to point sources.
- Examples:

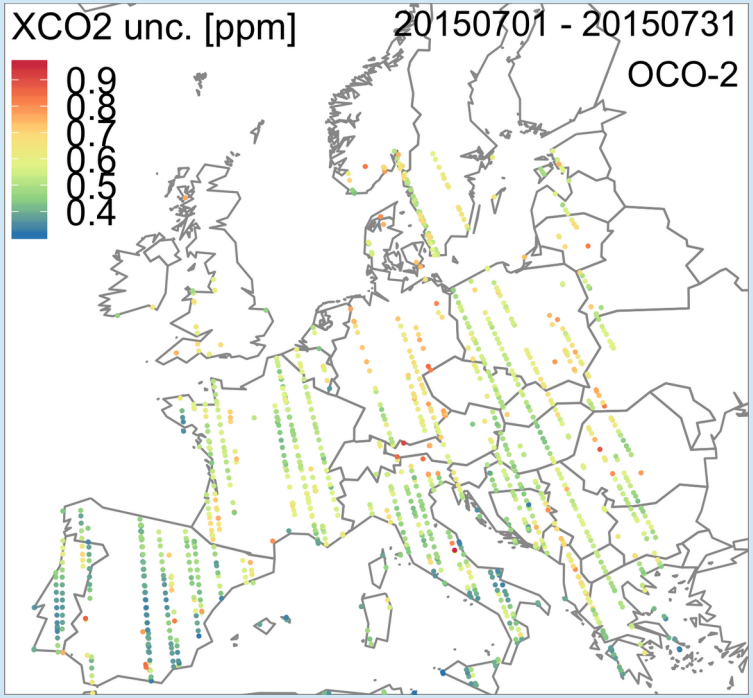




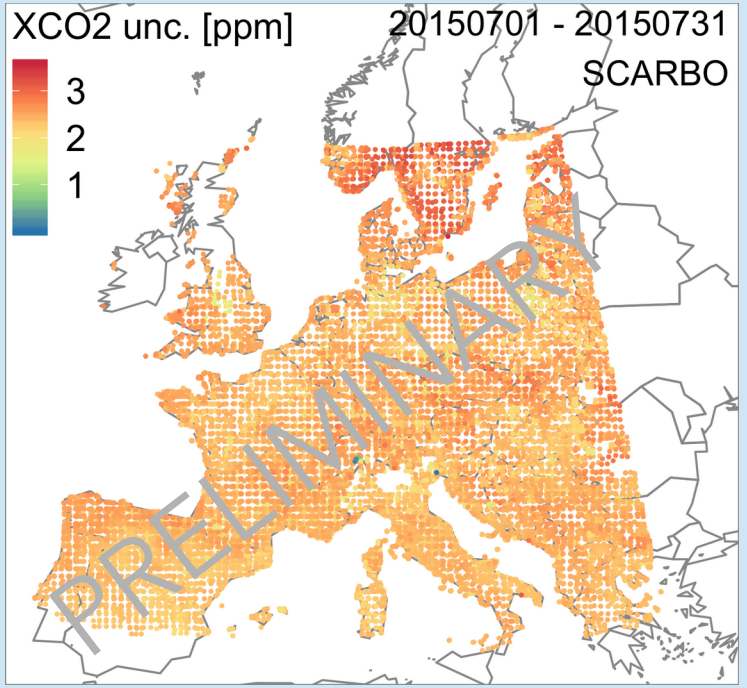
Domain	Europe	Berlin
Resolution	36 km	1.3 km resolution (inner nested domain)
Target	Country-scale CO2 OSSE (SCARBO)	Anthropogenic CO2 OSSE (CHE)

Application of CTDAS-WRF: OCO-2 vs SCARBO

- Compare OCO-2 vs SCARBO flux estimation capability in CTDAS-WRF.



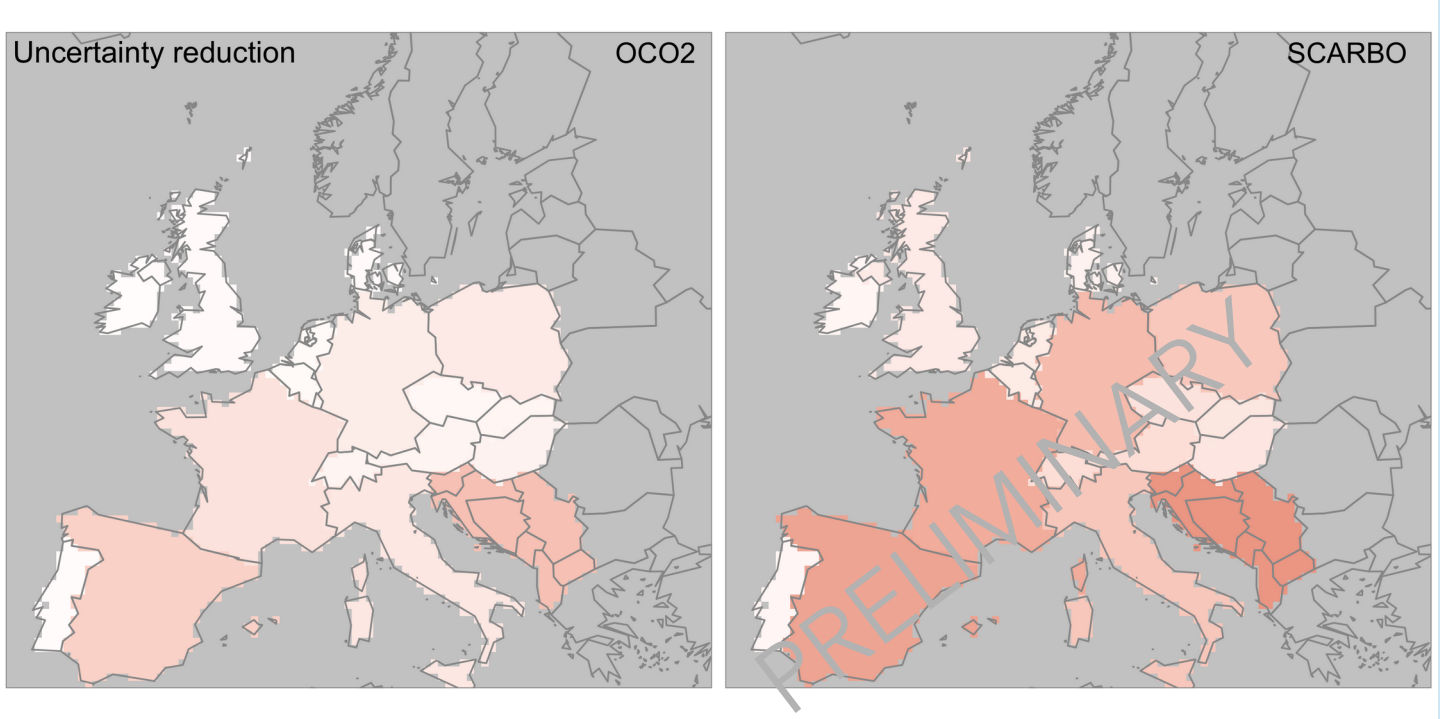
OCO-2 v9 observations, random uncertainties



Synthetic SCARBO observations. Random uncertainties are preliminary and overestimated.

OCO-2 vs SCARBO

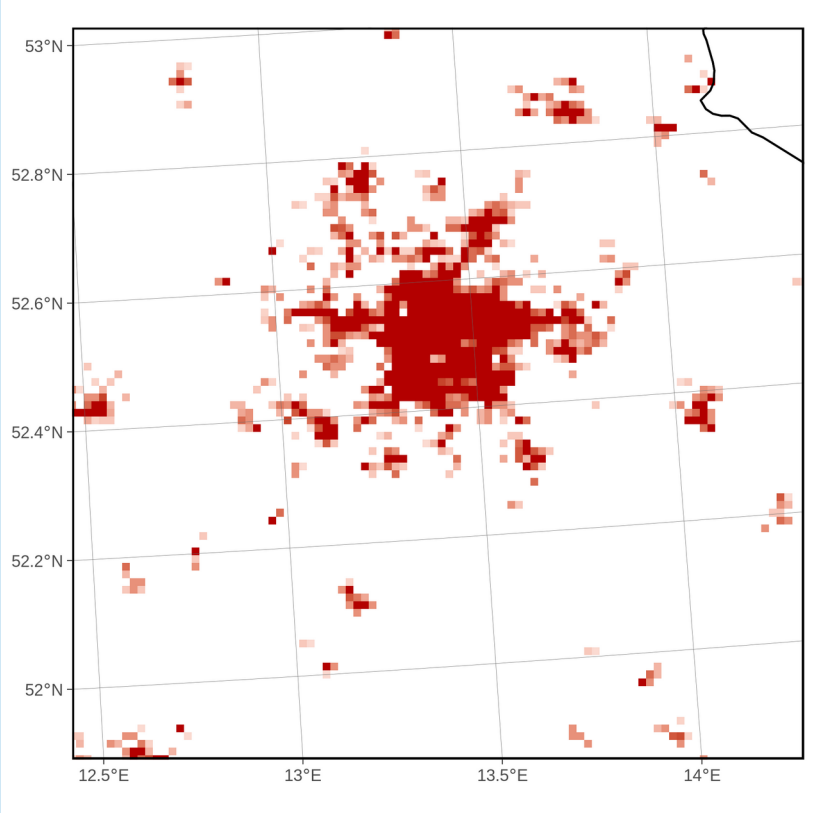
- Daily flux uncertainty reduction: **SCARBO has the potential to outperform OCO-2** (even with preliminary overestimated random uncertainties)



Random flux uncertainty reduction = $1-\sigma_{optimized}/\sigma_{prior}$. Darker = better. Scale not shown because results are preliminary.

Outlook: city-scale flux optimization with CO2M

- City-scale CO2 emissions are one target of planned CO2M mission
- We plan to simulate CO2M's capability to retrieve CO2 fluxes from Berlin, Beijing and Shanghai
- Basis is synthetic CO2M uncertainties (Johan Strandgren, DLR)



Urban area fraction in Berlin domain

Summary

- Developed CO2 flux optimization model CTDAS-WRF, which is a modification of CTDAS that uses WRF-Chem for atmospheric transport
- Code available from authors and in the future from git.wur.nl/ctdas
- Possible applications include scales from continental fluxes to point sources
- Preliminary SCARBO results show its potential benefit over OCO-2

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