

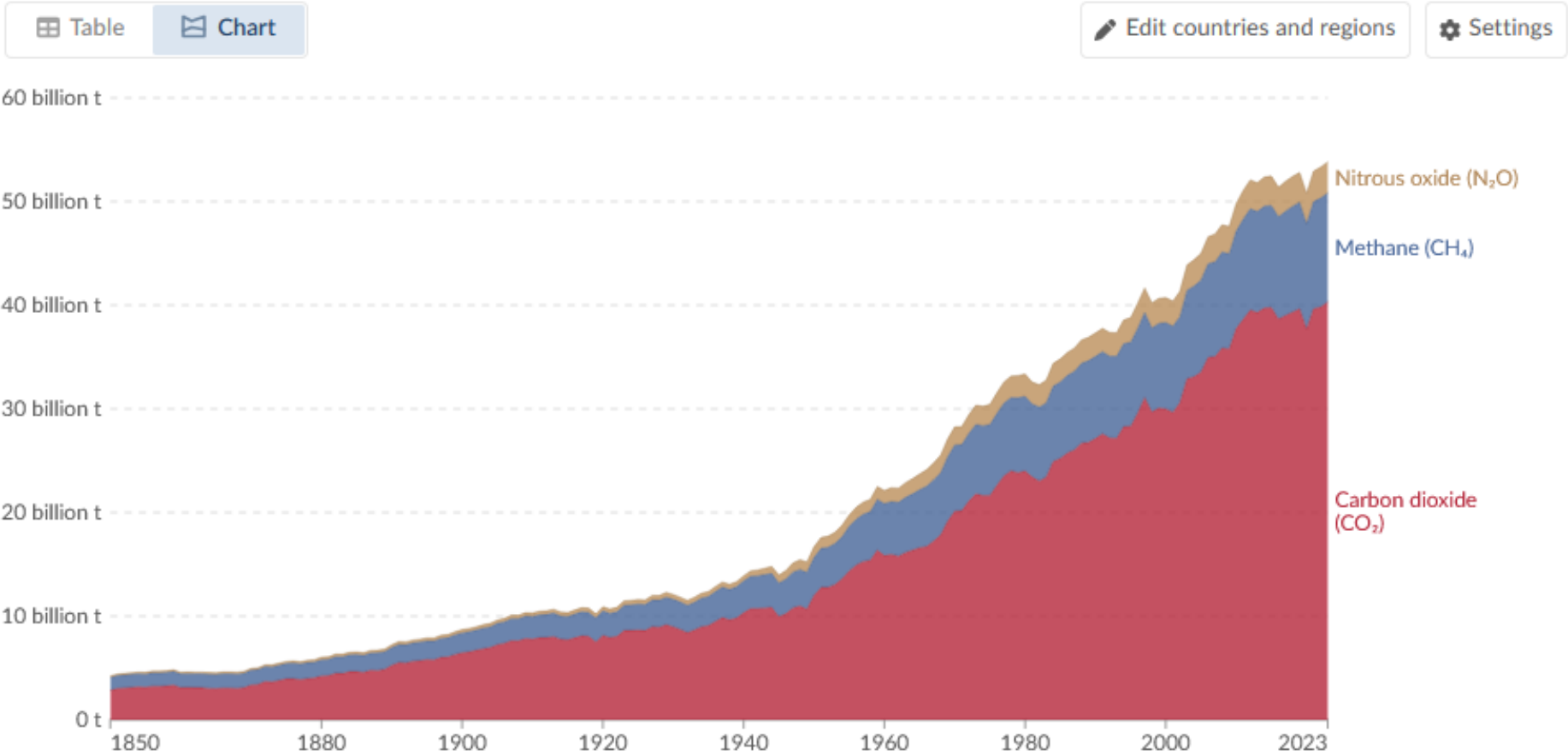
The potential of improving the estimation of national biogenic greenhouse gas emissions via the integration of crop identity

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Greenhouse gas emissions by gas, World, 1850 to 2023

Our World
in Data

Greenhouse gas emissions from all sources, including agriculture and land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.



Greenhouse gas emissions by gas, World, 1850 to 2023



Greenhouse gas emissions from all sources, including agriculture and land-use change. They are measured in tonnes of carbon dioxide-equivalents over a 100-year timescale.

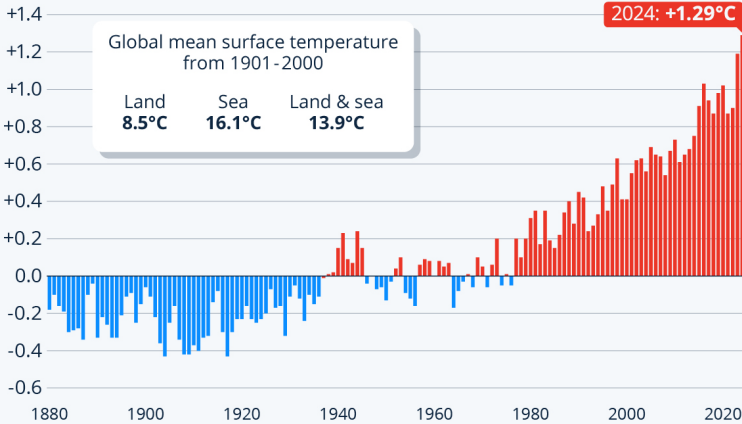
Table

Edit countries and regions

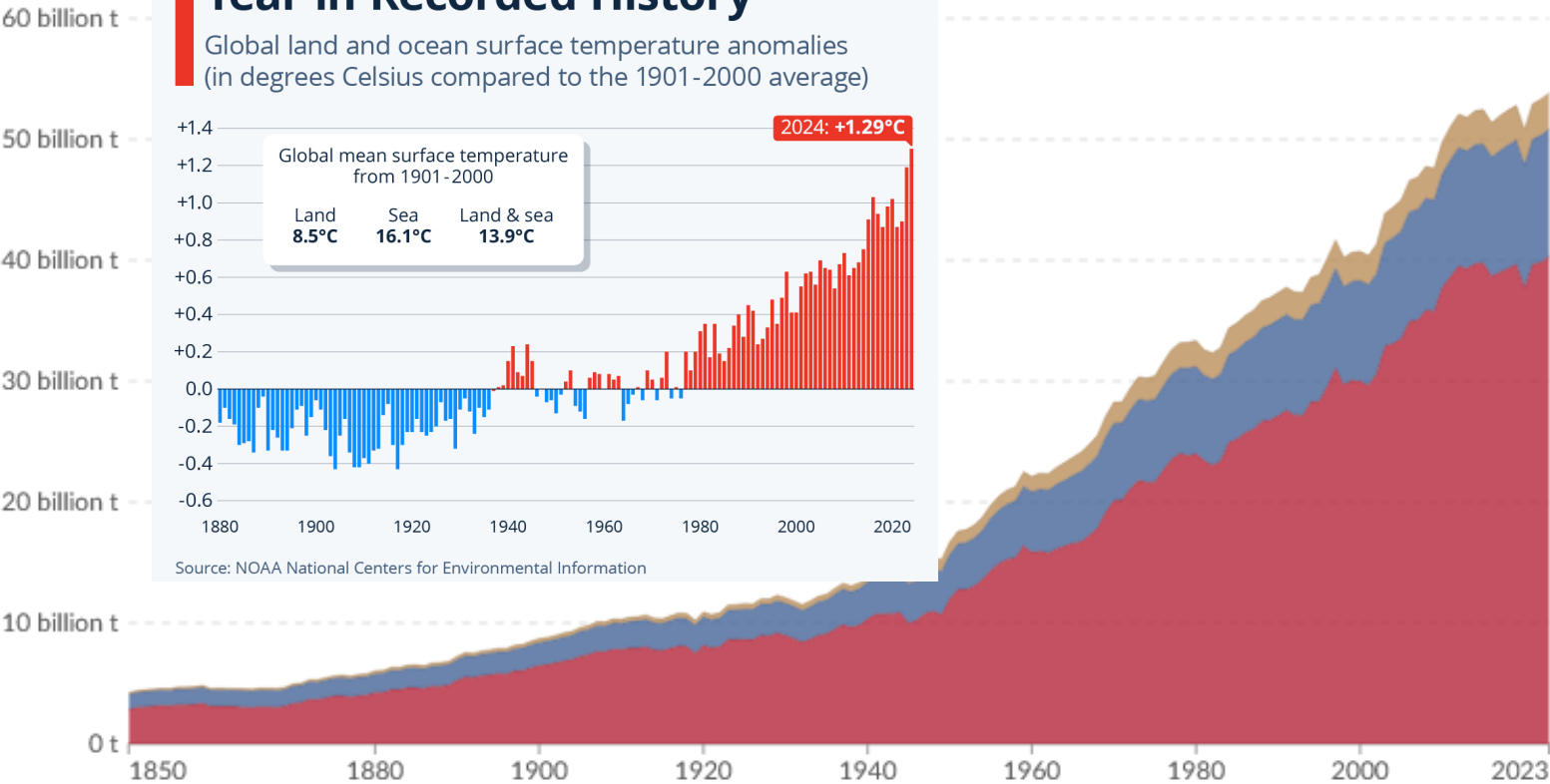
Settings

2024 Was the Planet's Warmest Year in Recorded History

Global land and ocean surface temperature anomalies (in degrees Celsius compared to the 1901-2000 average)



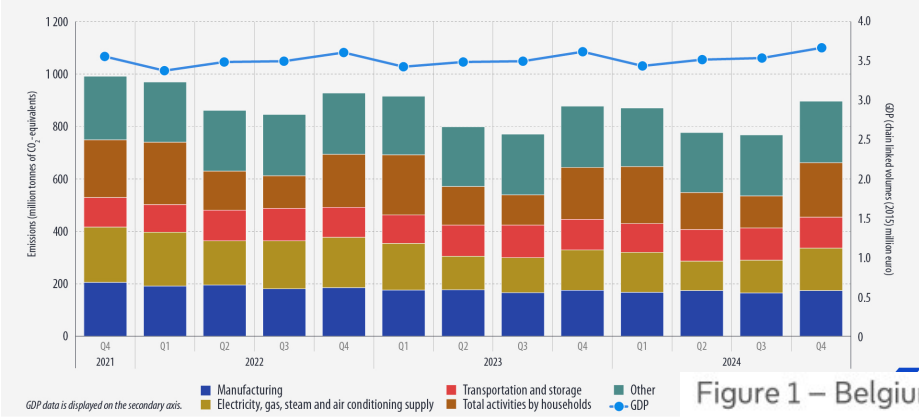
Source: NOAA National Centers for Environmental Information



Global warming trends and GHG emissions

Greenhouse gas emissions by the economy and GDP in the EU, Q4 2021 - Q4 2024

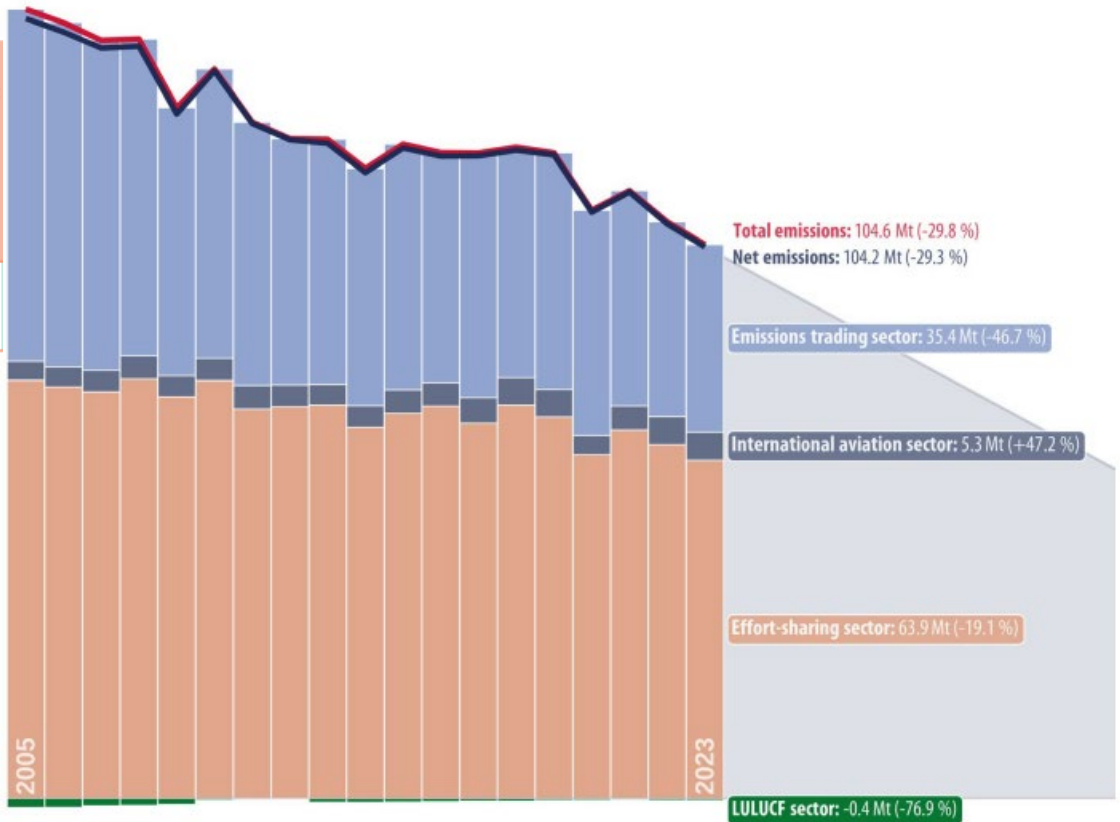
(million tonnes of CO₂-equivalents, chain linked volumes (2015) million euro)

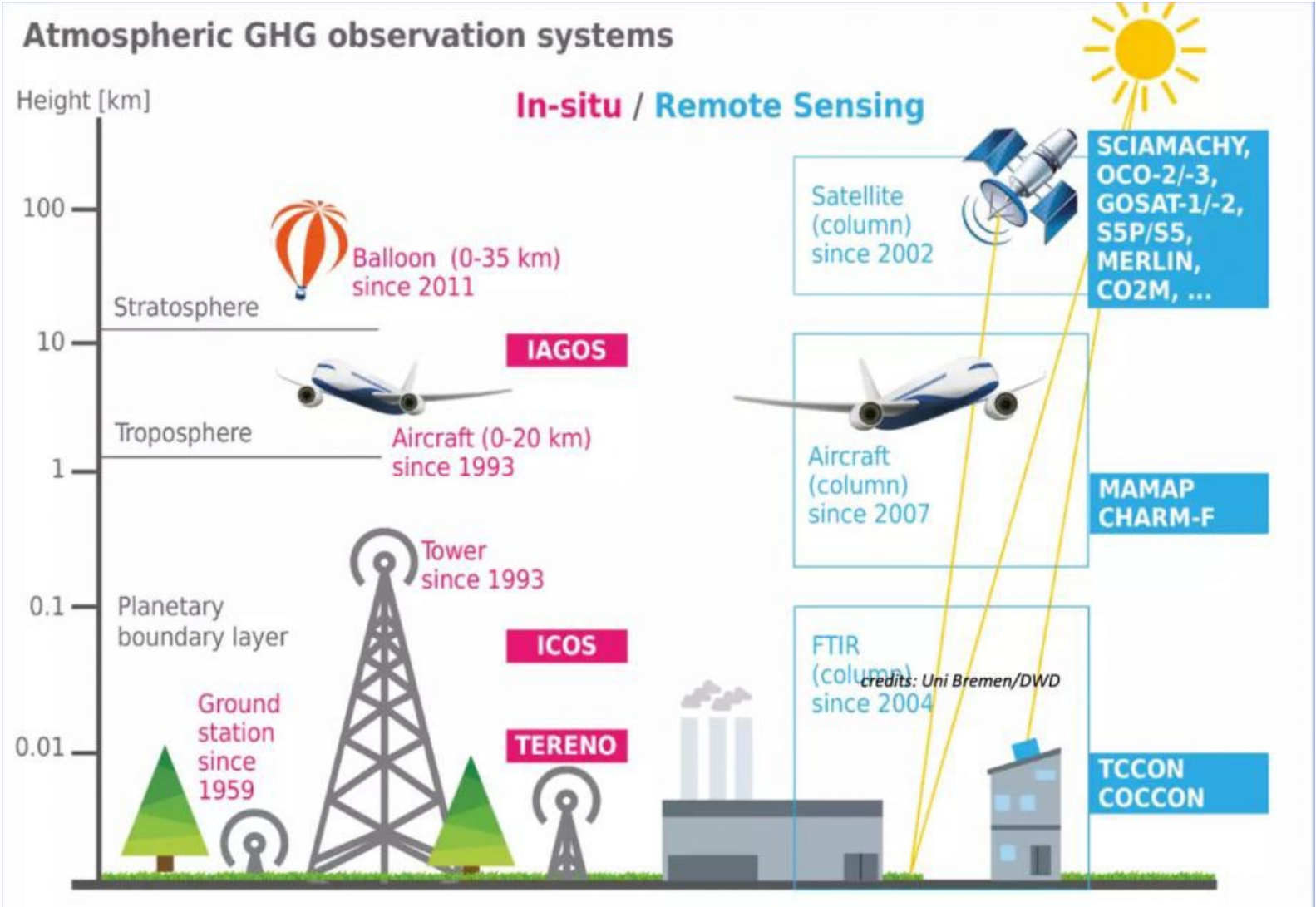


EU targets compared to emission levels of 1990:

- 2030: 55% (new target 66.25 – 72.5%)
- 2040: 90% (now with 5% carbon credit)
- net neutrality by 2050

Belgium	Total net GHG emissions 2022-1990 (% change)			Total net GHG emissions 2022-2015 (% change)			GHG intensity of GDP 2022-2015 (% change)			Projected net GHG emissions by 2030 (tonnes per capita)			Projected net GHG emissions by 2050 (tonnes per capita)		
	-26%			-10%			-19%			7.0			5.2		
	-32%			-10%			-20%			5.1			3.6		
EU27	Overshoot vs. linear trajectory (net GHG emissions 2022-2050)		Overshoot vs. non-linear benchmark (total GHG emissions 2022-2050)		Target year for climate neutrality (NECP progress reports, national long-term strategies or "x" other sources)		Legal status of the climate-neutrality target (based on the Net-Zero Tracker)								
	49%		21%		2050*		In policy document								
	34%		40%		2050		In law								



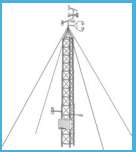


- “Expensive”
- Point measurements (but with footprint)
- Exact fluxes but no concentration

- “Cheap”
- Flaws in temporal/spatial resolution
- Column prevents origin/transport attribution

Atmospheric inversion

Fluxtower
EC data



UPSCALE

“Prior”-fluxes
Across region of
interest

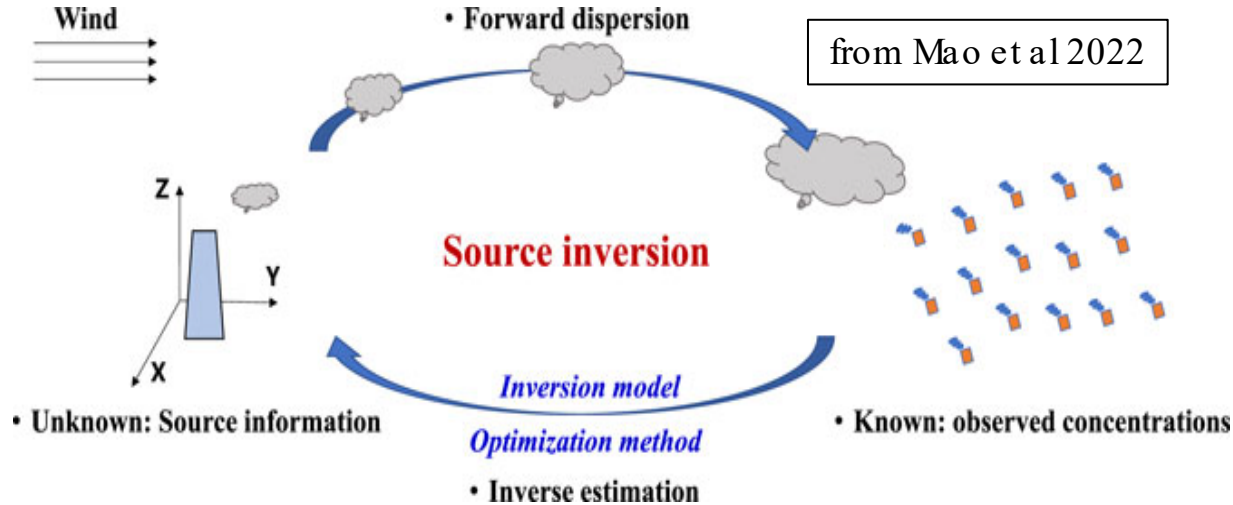


Atmospheric
Transport Model
(e.g. WRF-Chem)



Atmospheric
GHG
concentrations

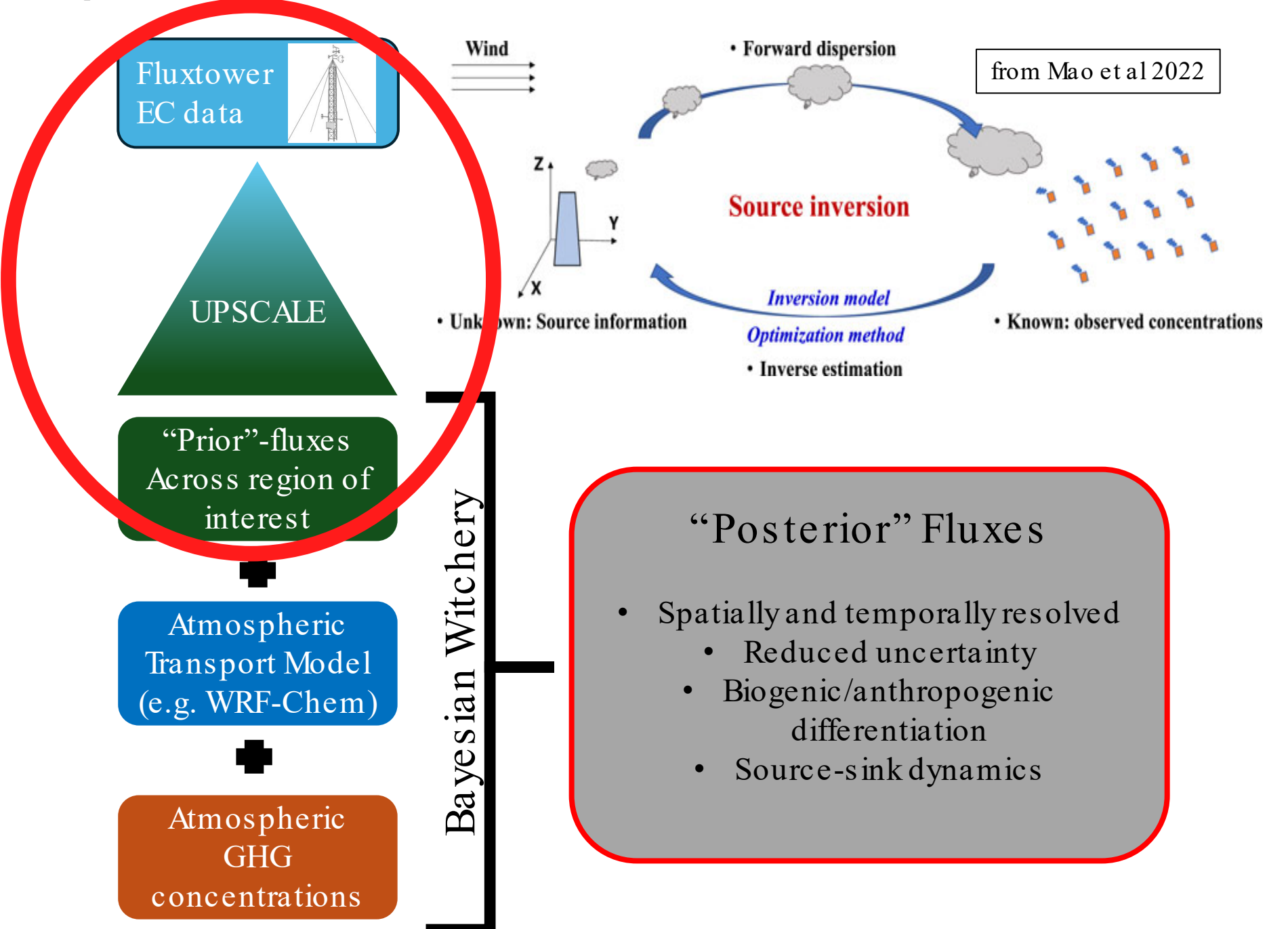
Bayesian Witchery

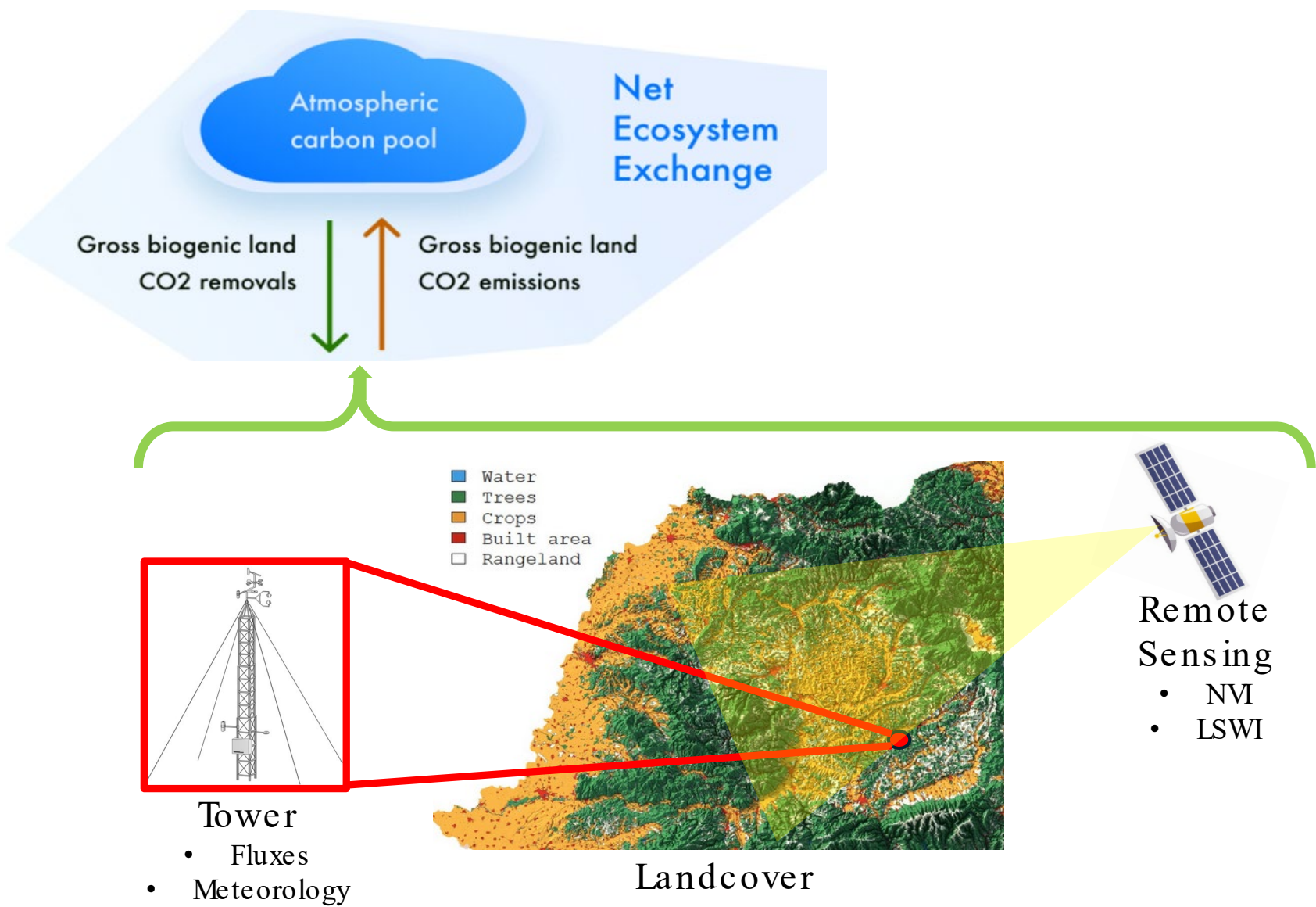


“Posterior” Fluxes

- Spatially and temporally resolved
 - Reduced uncertainty
 - Biogenic/anthropogenic differentiation
 - Source-sink dynamics

Atmospheric inversion



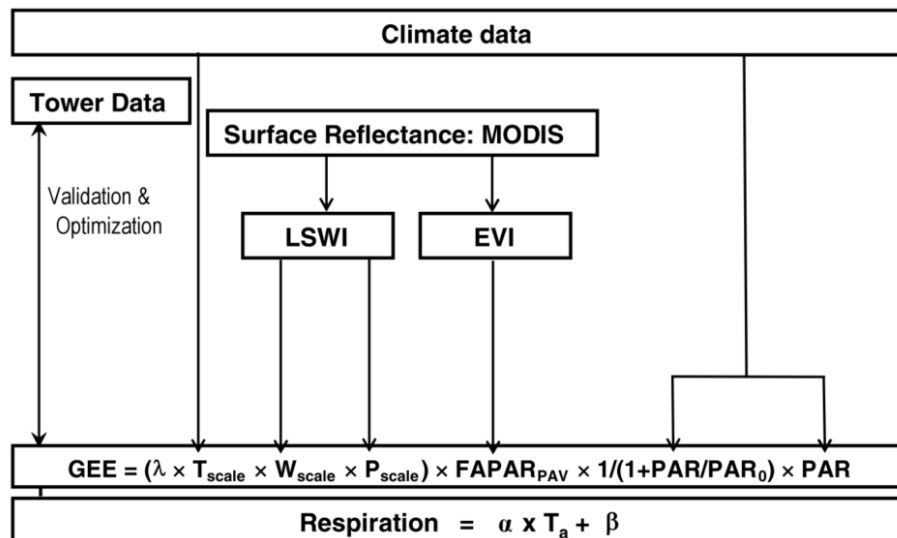


Simulating CO₂ fluxes bottom-up via flux-tower, satellite and meteorology data:

Vegetation Photosynthesis is Respiration Model (VPRM)

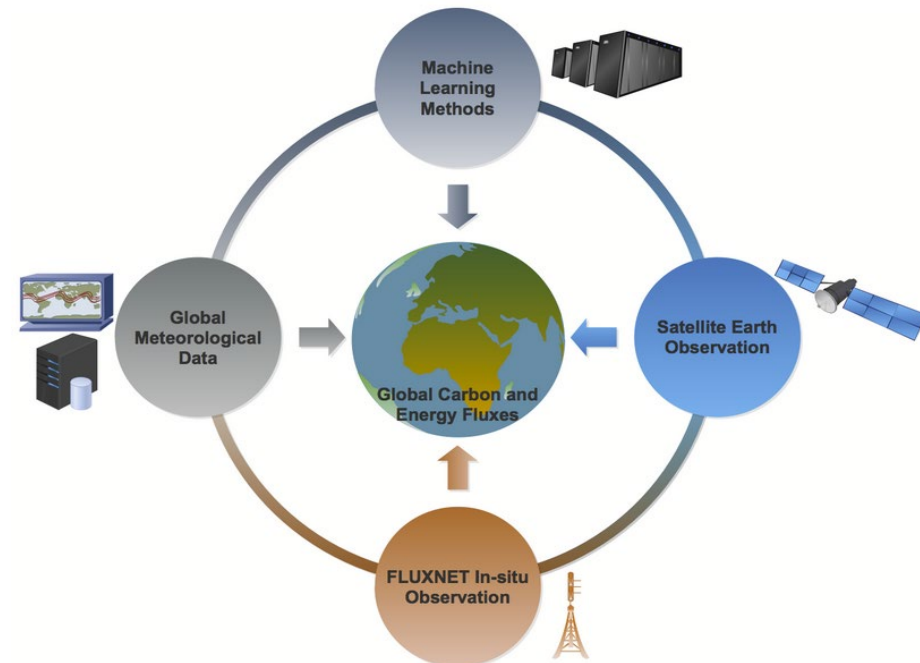
- Well established and widely used (Mahadevan et al 2008)
- Equation based
- Landcover based on SYNMAP (Jung et al 2006) in 1 km resolution
- Available in hourly average 2012-2023 (2019 missing) in 0.125° x 0.083° resolution for Belgium

MAHADEVAN ET AL.: NET ECOSYSTEM EXCHANGE MODEL

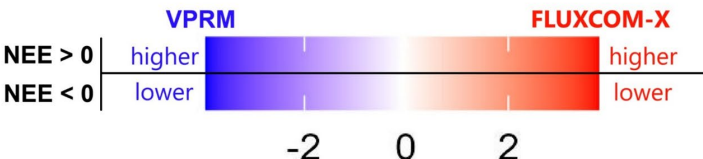
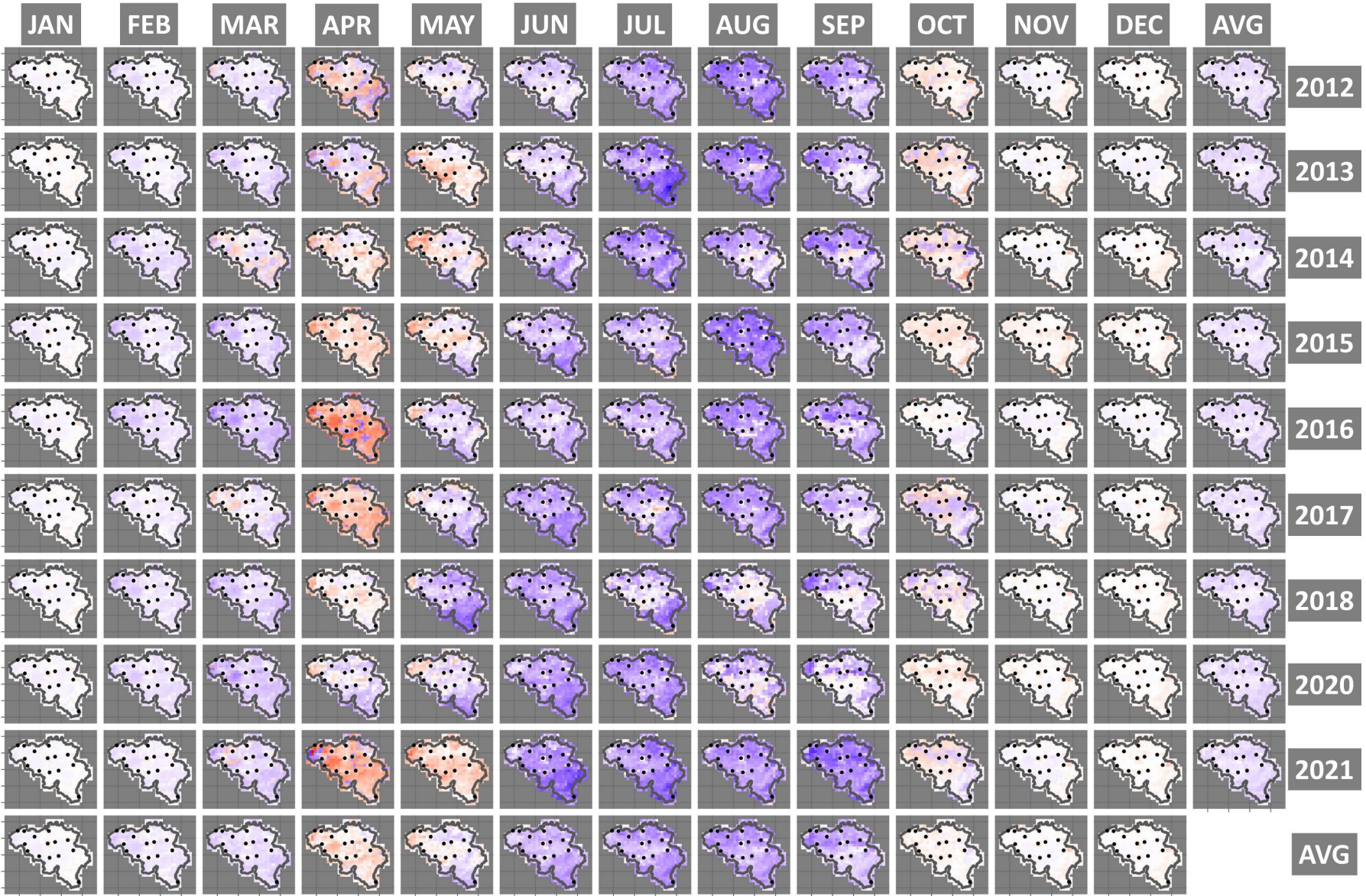


FLUXCOM-X

- new and hot
- Machine learning based (boosted regression trees)
- Landcover based on MODIS MCD12Q1 (Friedl et al 2019) in 500m resolution
- Available in monthly average 2012-2021 in 0.05° x 0.05° resolution for Belgium

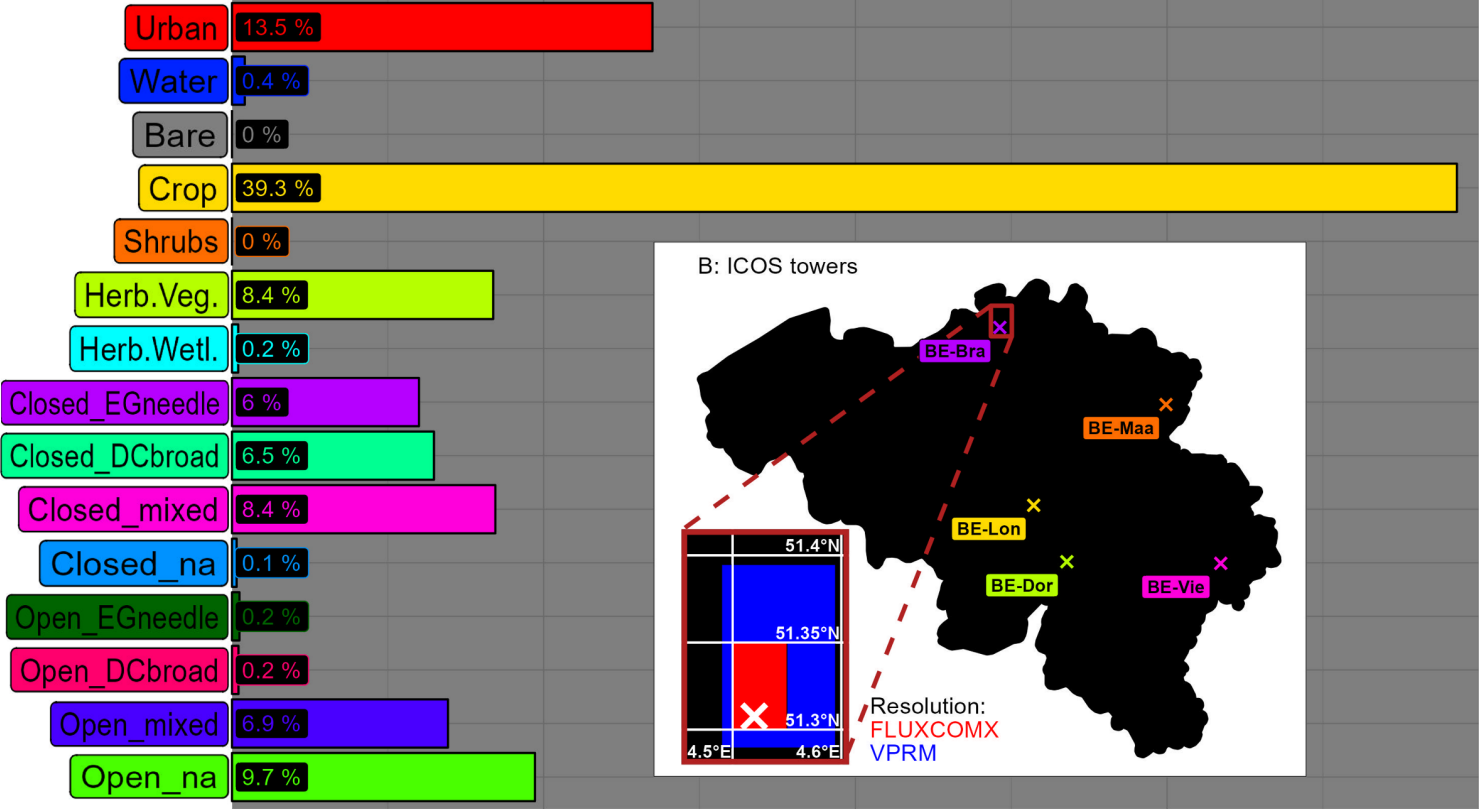


A general overview of the FLUXCOM initiative.



VPRM vs. FLUXCOM-X

A: Landcover composition Belgium 2019



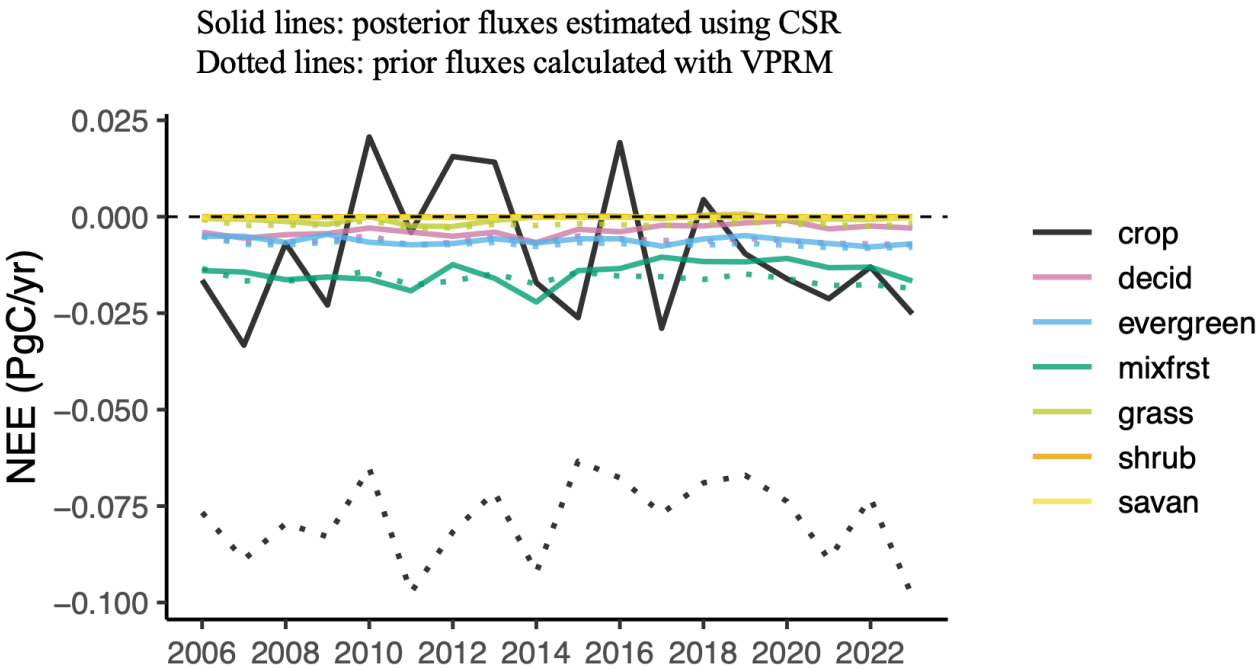
Landcover	BEL LC (%)	Dif. VPRM (gC/m ² /d)	Dif. FC-X (gC/m ² /d)
Cropland (BE-Lon)	39.3	1 ±2.7	0.9 ±2.8
Closed mixed forest (BE-Vie)	8.4	-0.3 ±0.9	0.2 ±0.8
Herbal Vegetation (BE-Dor)	8.4	0.1 ±2.1	0.2 ±1.4
Evergreen needle forest (BE-Bra)	6	-0.3 ±1.1	0.1 ±1.3
Shrubs (BE-Maa)	0.1	-0.3 ±1	0.1 ±0.5



Estimated CO₂ fluxes for different vegetation classes over Germany

Vegetation types:

- Cropland (crop)
- Deciduous forest (decid)
- Evergreen forest (evergreen)
- Mixed forest (mixfst)
- Grassland (grass)
- Shrubland (shrub)
- Savanna (savan)

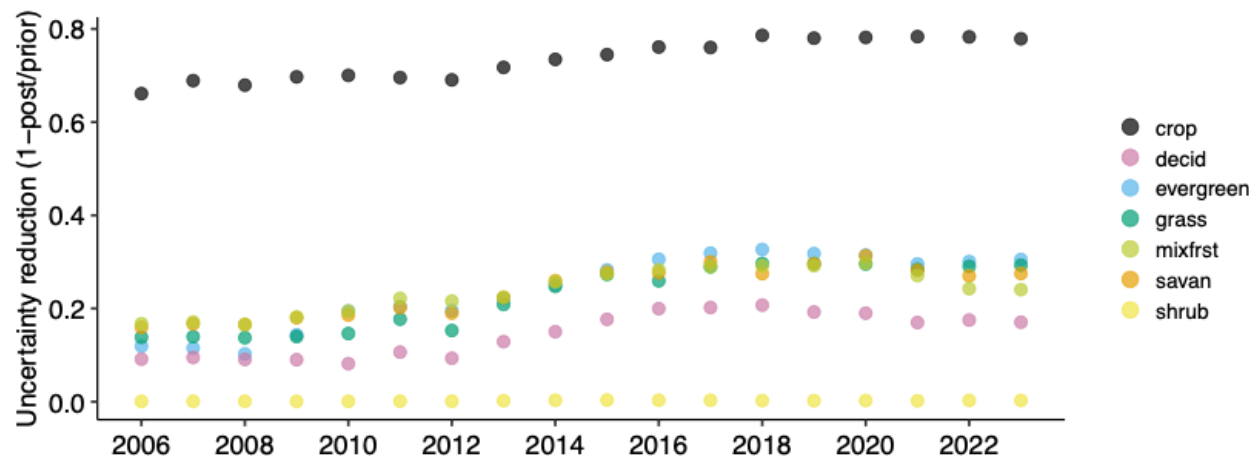


Thanks to Dr. Saqr Munassar
(Max-Planck Institute for Biogeochemistry,
Jena GER)



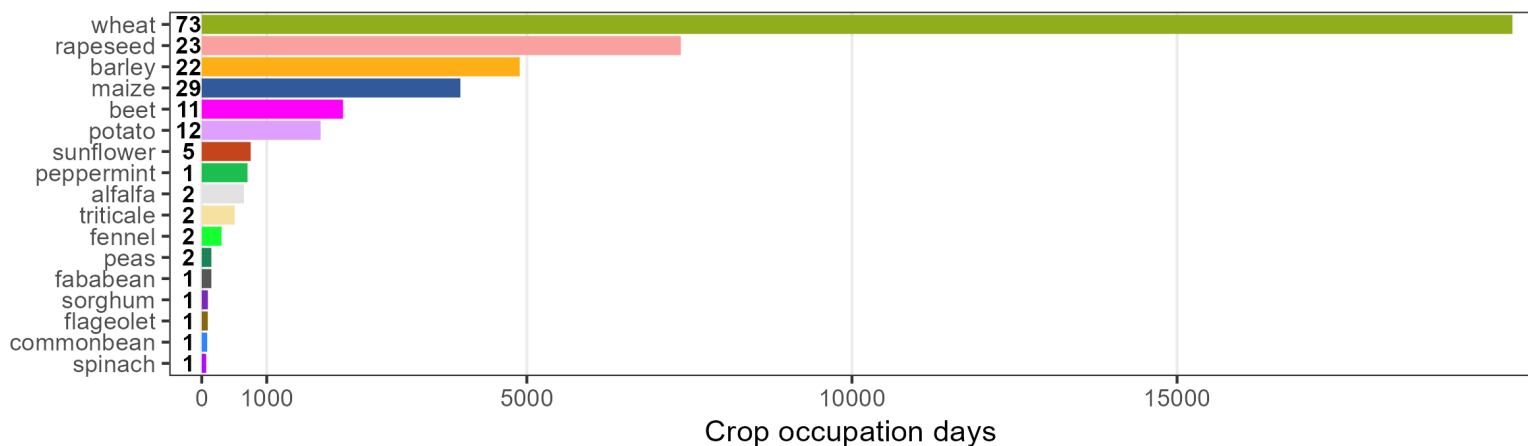
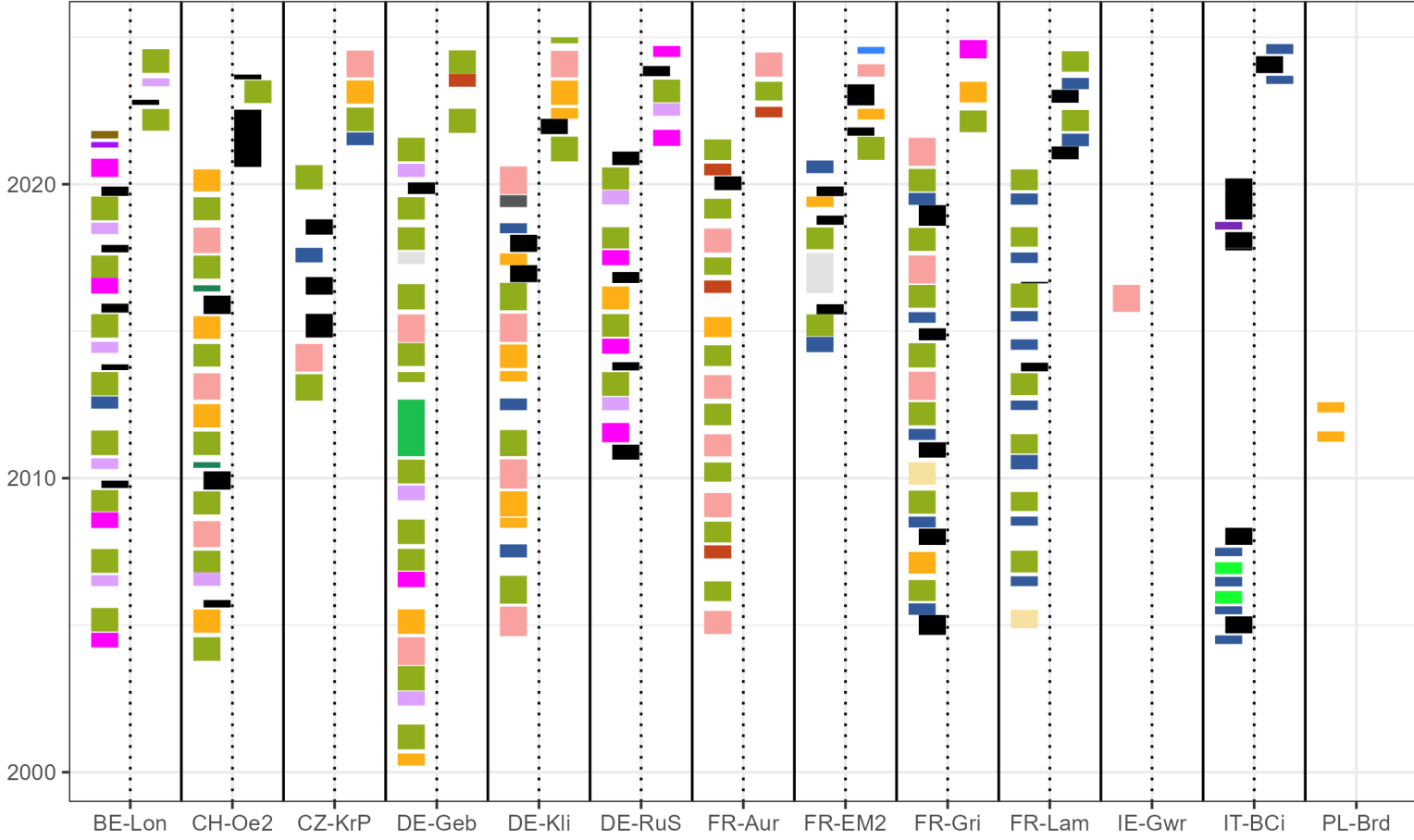
Posterior uncertainty reduction

- ❑ Prior uncertainty assigned to each class according to the fractional contribution to total fluxes
- ❑ Crop flux estimates show largest posterior uncertainty reduction.
- ❑ Recent years exhibit larger uncertainty reduction of flux estimates than in early years, due to improvements in spatial coverage of observations.

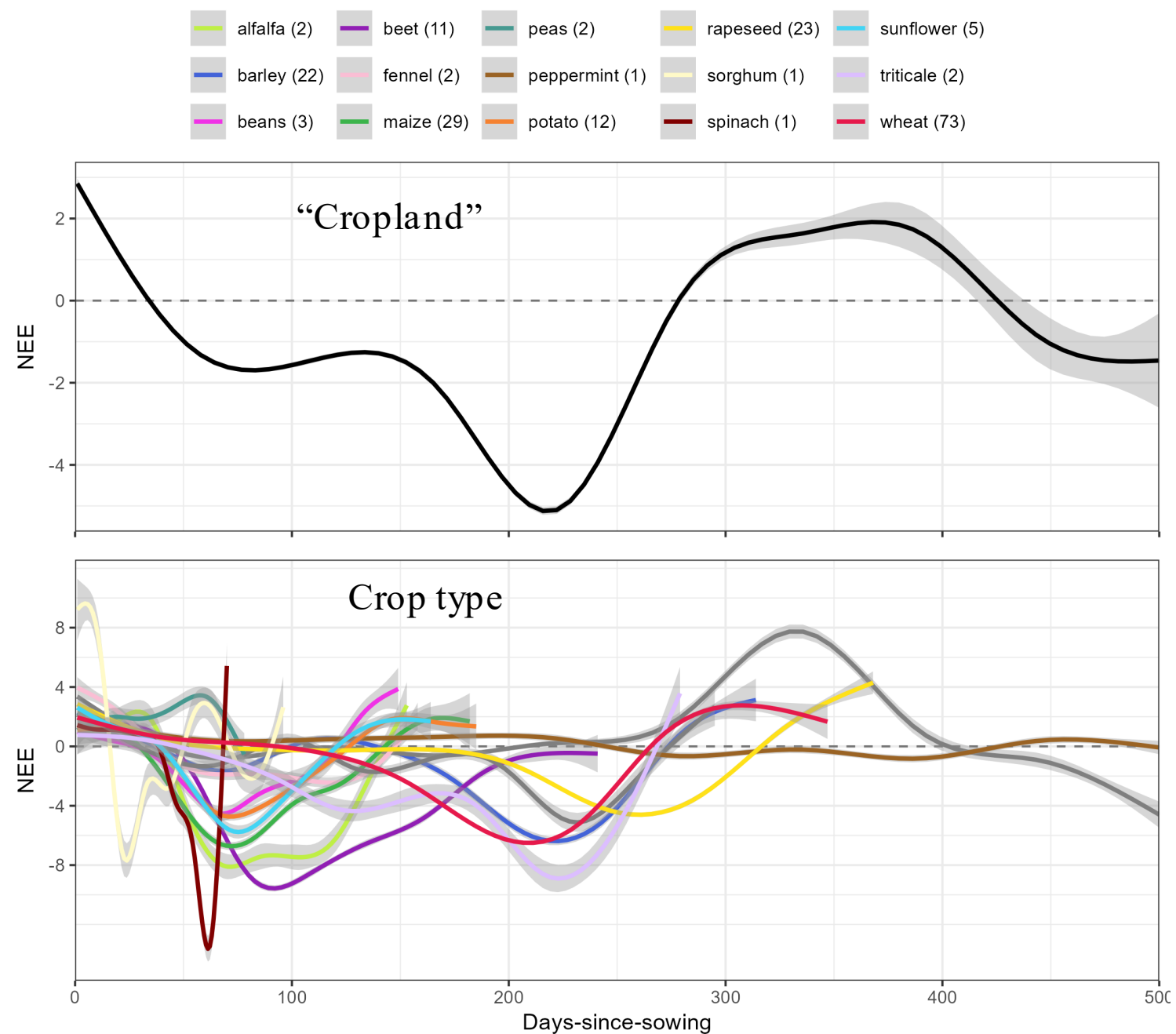


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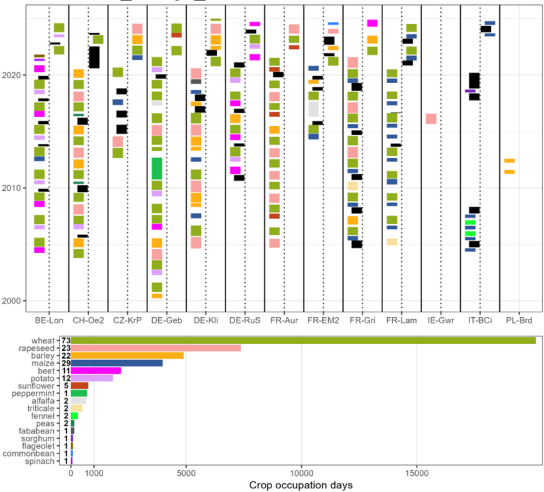
Crop type integration



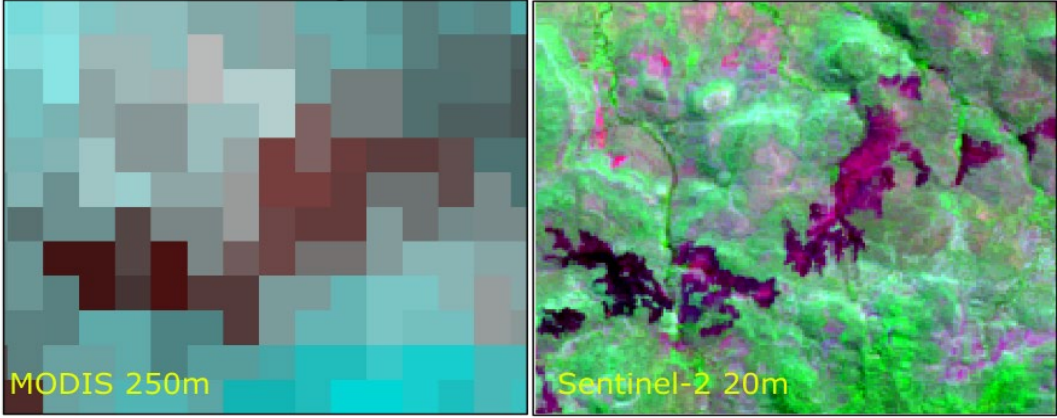
Crop type integration



Crop type EC fluxdata



Sentinel-2 high resolution images since 2017



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Classical VPRM

Reconfigured
VPRM_{crop}

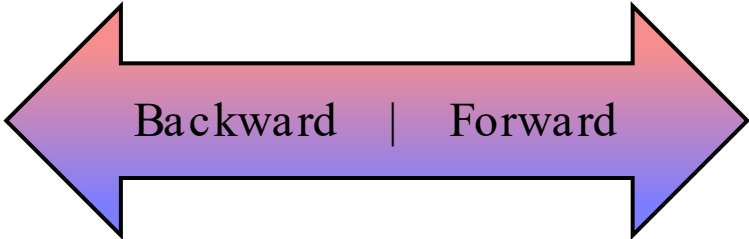
Classical
FLUXCOM-X(like)

Crop resolved
FX_{crop}

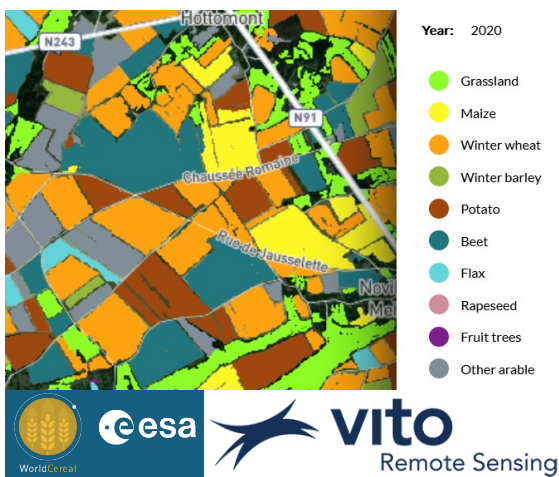
Crop type integration



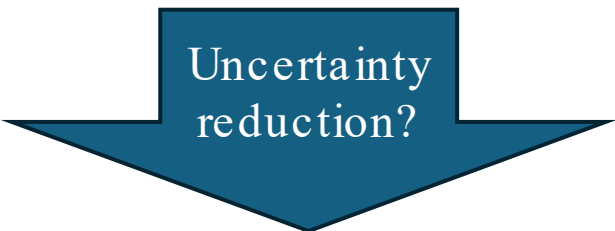
Farmer Crop reporting



Remote sensing Crop ID

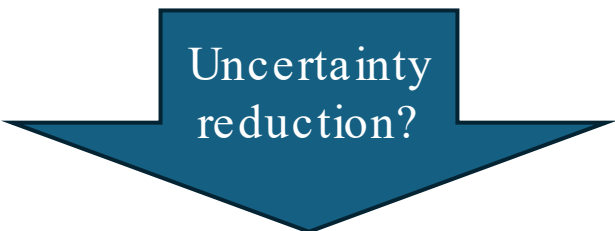


Classical VPRM



Reconfigured VPRMcrop

Classical FLUXCOM-X(like)

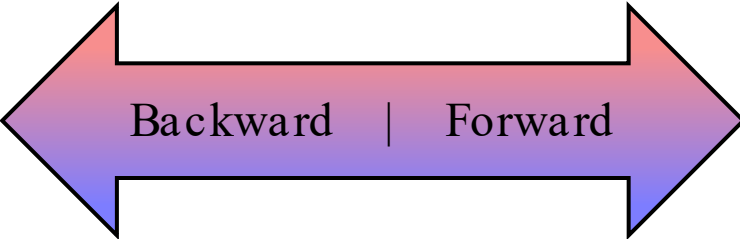


Crop resolved FXcrop

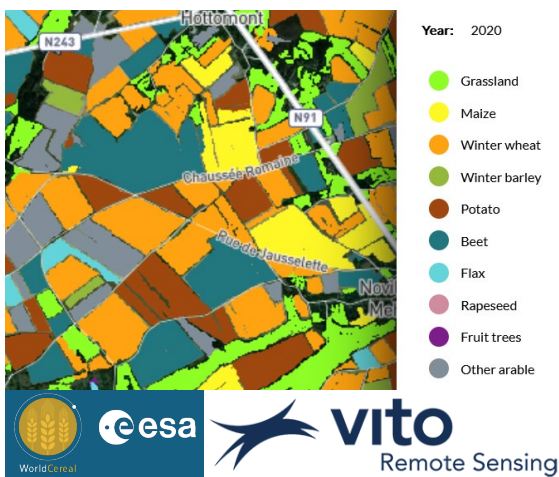
Crop type integration



Farmer Crop reporting

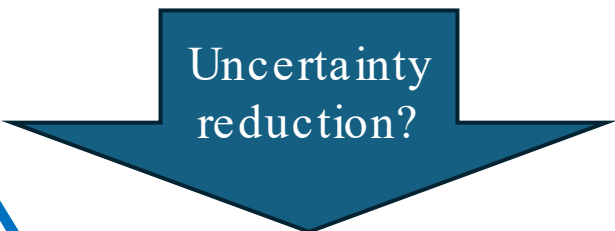
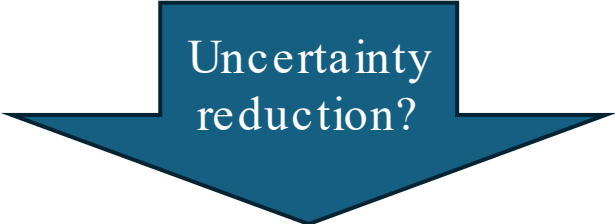


Remote sensing Crop ID



Classical VPRM

Classical
FLUXCOM-X(like)



Fluxtower
EC data

Accuracy improvement?

Reconfigured
VPRMcrop

Crop resolved
FXcrop

Thank you for your attention!

Questions?