

High-resolution, crop-specific VPRM estimates for Belgium

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VERBE project and objectives

In the context of the Paris Agreement, the VERBE project aims to build a dedicated observation infrastructure accompanied by a dedicated inversion framework for Belgium, to establish a sustainable Belgian observation- and model-based Emission Monitoring and Verification System (MVS) for emissions of greenhouse gases (GHG).

› Focus on **CH₄, CO₂ and N₂O**

› 4-year project, funded by Belgian Science Policy Office (BELSPO), End of project: Dec 2026

› Related long-term project (10 years): BE-MVS, structural collaboration between BIRA-IASB and UAntwerp

- **New** additional atmospheric ICOS- and TCCON-type **observations of GHG in Belgium**
- An inverse modelling **framework** for GHG for Belgium, based on WRF-Chem
- A **demonstration of the added-value** of providing top-down information about GHG emissions for Belgium
- **An indication of the potential** to reduce uncertainties in the bottom-up inventories and of the potential of the initiated system to become a key decision support tool for stakeholders and policymakers
- Provide **spatially resolved** feedback of the bottom-up emission inventories
- A **roadmap** to further improve and sustain the MVS capacity in Belgium



Task Improve the estimation of biogenic greenhouse gas emissions for the Belgian domain to reduce uncertainty as prior fluxes in the atmospheric inversion.

- Commonly used **models**, such as **VPRM** or **FLUXCOM-X**, that connect fluxtower measurements with satellite indices and meteorological data to upscale the estimations via predicting over a larger spatial scale **differ considerably in their accuracy for different landcover types**.
- **Permantent, large-scale, uniform landcovers** (such as forests and grassland) are upscaled with already **reasonably high precision** (Tab.1) as they do not change substantially over time, are captured spatially by lower resolution satellite images (eg. MODIS) and have a lot of measured fluxdata available.
- The contrast is the commonly used **cropland landcover class** for which the upscaled flux predictions **remain highly inprecise with a large connected uncertainty** (Tab.1) due to:
 - **Crop species turnover** within (summer/winter crop season), across years (crop rotation) and at times completely bare of any vegetation
 - **Crop species differ** considerably in their **flux-profile** leading to high inprecision when combined in a model (Fig.1).
 - **Mosaic-like structure of small fields** (for most of Europe) that is not resolvable by lower-resolution satellite imagery.
 - Considerably **less available fluxdata** per crop species.
- Therefore **cropland, the major landcover in Belgium** (and most of Europe, Tab. 1) is very **imprecisely estimated** when upscaling its **flux estimations**.
- **CropFlux** solves this by combining:
 - high-resolution **Sentinel-2 indices** (EVI and LSWI)
 - **crop-specific fluxtower measurements** of 11 fluxtowers
 - **VPRM model** (adapted from pyVPRM) to upscale **NEE and GPP**
 - **landcover maps** that resolve the cropland landcover class into **individual crop species**.

Figure 2: Crop occupancy data from 11 cropland fluxtowers (map inset lower right) with colour indicating crop species and black indicating any covercrop. The gaps in between bars are considered bare soil while the grey line showing the start of Sentinel-2 availability. The lower graph shows the total number of crop-cycles (sowing to harvesting, bold number at the start) and the total number of occupancy days per crop species.

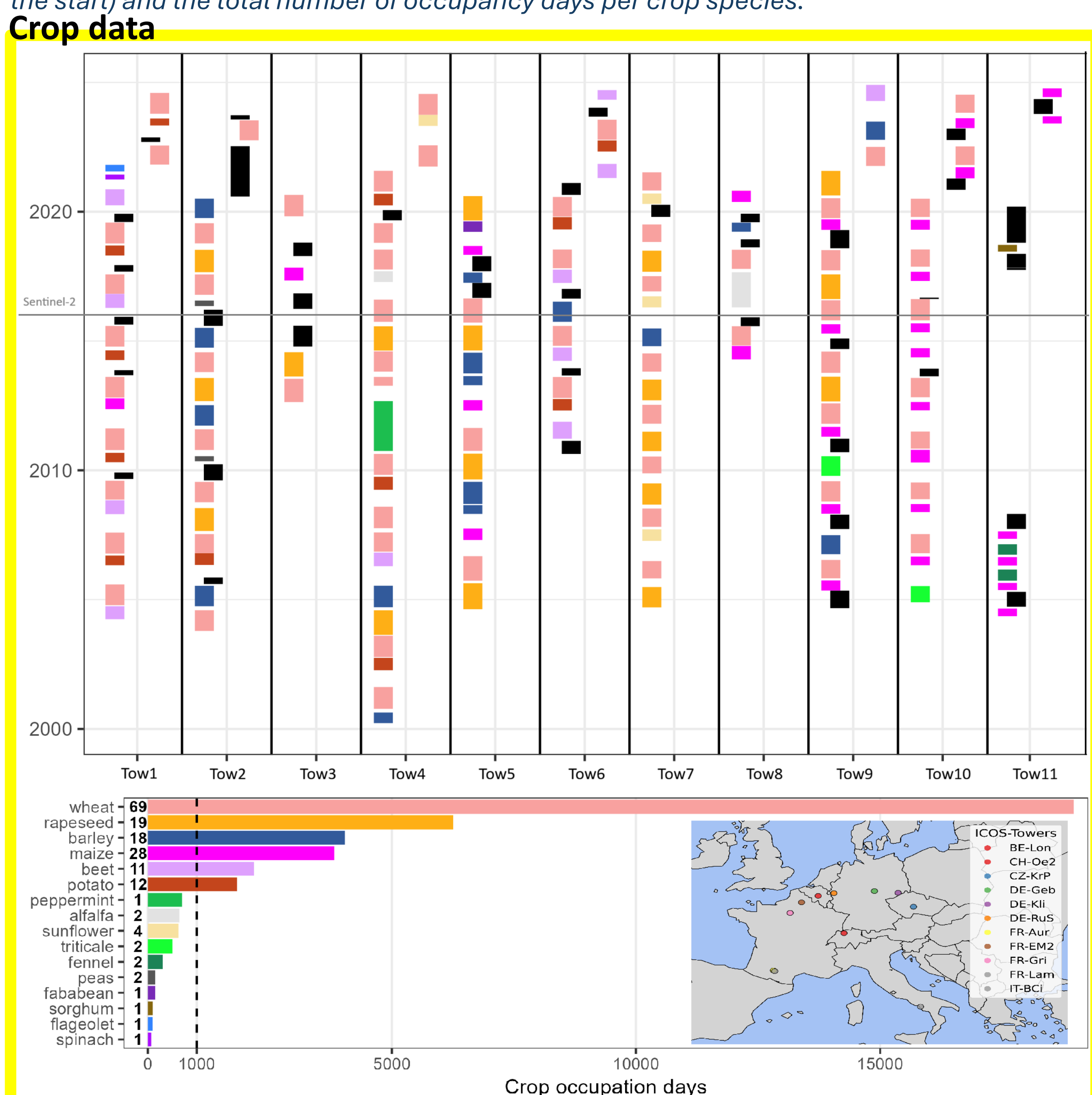


Figure 3: Landcover maps integrating crop occupancy for 10 km area around BE-Lon in a 10m resolution for three years.

Environmental data

- Sentinel-2 based EVI, LSWI and SCL masking via the VITO openEO framework to limit local memory usage and download size
- Temperature and shortwave-radiation data from ERA5 with potential additional integration of soil moisture in final product

CropFlux

Model

- Establishes Tmin, Topt, Tmax and Tlow via fluxtower GPP measurements from all available crop occupancy data
- Establishes α , β , λ and par0 VPRM parameters via pyVPRM over Sentinel-2 timeframe
- Currently for 8 crop species (see landcover legend) + covercrop + bare

Prediction

- Estimates net-ecosystem-exchange (NEE) and gross-primary-production (GPP) in 20m resolution
- Meteorology (temperature and radiation) via ERA5
- Landcover maps in Sentinel-2 resolution currently configured by official data provided by farmers to regional governments
- In final product usage of WorldCereal suite to allow more general wider application and data reliability
- Predictions planned twice per year (summer/winter crop season)

Currently work on first demonstration on 10 km area around BE-Lon.

Landcover maps

