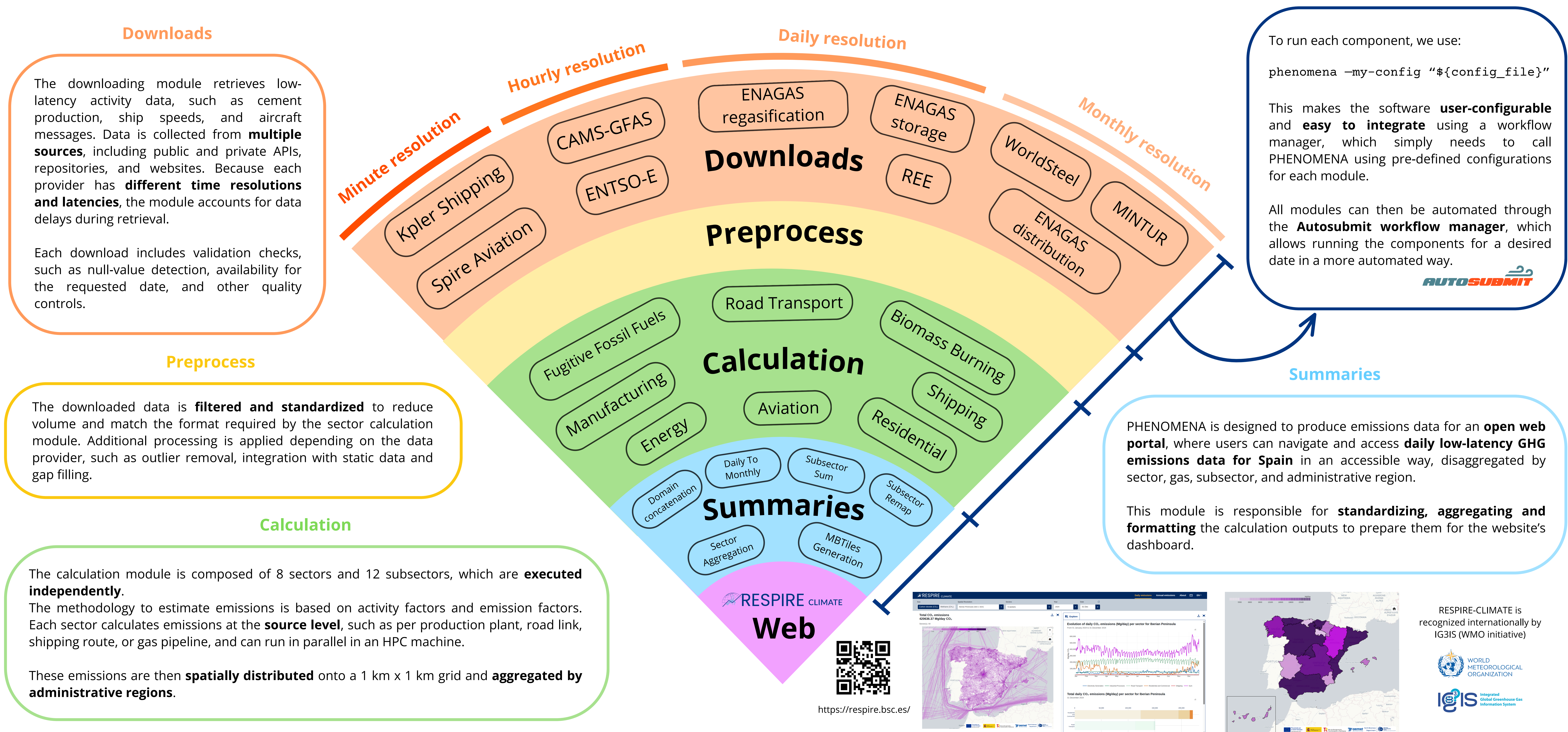


PHENOMENA: a modular HPC model to facilitate automatic high-resolution greenhouse gas emission monitoring

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PHENOMENA (sPanish Emission mOnitoring system for grEenhouse gAses) is a **Python-based, open-source, multiscale emission model** that computes **high-resolution** (up to 1km² and daily) and **low-latency** greenhouse gas (GHG) emissions for Spain. It uses a bottom-up approach, is based on the OOP paradigm, and is **designed to run on High Performance Computing (HPC) infrastructures**. Thanks to its modular structure, it is also **easily adaptable** for other regions and data.



Downloads

The downloading module retrieves low-latency activity data, such as cement production, ship speeds, and aircraft messages. Data is collected from **multiple sources**, including public and private APIs, repositories, and websites. Because each provider has **different time resolutions and latencies**, the module accounts for data delays during retrieval.

Each download includes validation checks, such as null-value detection, availability for the requested date, and other quality controls.

Preprocess

The downloaded data is **filtered and standardized** to reduce volume and match the format required by the sector calculation module. Additional processing is applied depending on the data provider, such as outlier removal, integration with static data and gap filling.

Calculation

The calculation module is composed of 8 sectors and 12 subsectors, which are **executed independently**. The methodology to estimate emissions is based on activity factors and emission factors. Each sector calculates emissions at the **source level**, such as per production plant, road link, shipping route, or gas pipeline, and can run in parallel in an HPC machine.

These emissions are then **spatially distributed** onto a 1 km x 1 km grid and **aggregated by administrative regions**.

To run each component, we use:

```
phenomena -my-config "${config_file}"
```

This makes the software **user-configurable** and **easy to integrate** using a workflow manager, which simply needs to call PHENOMENA using pre-defined configurations for each module.

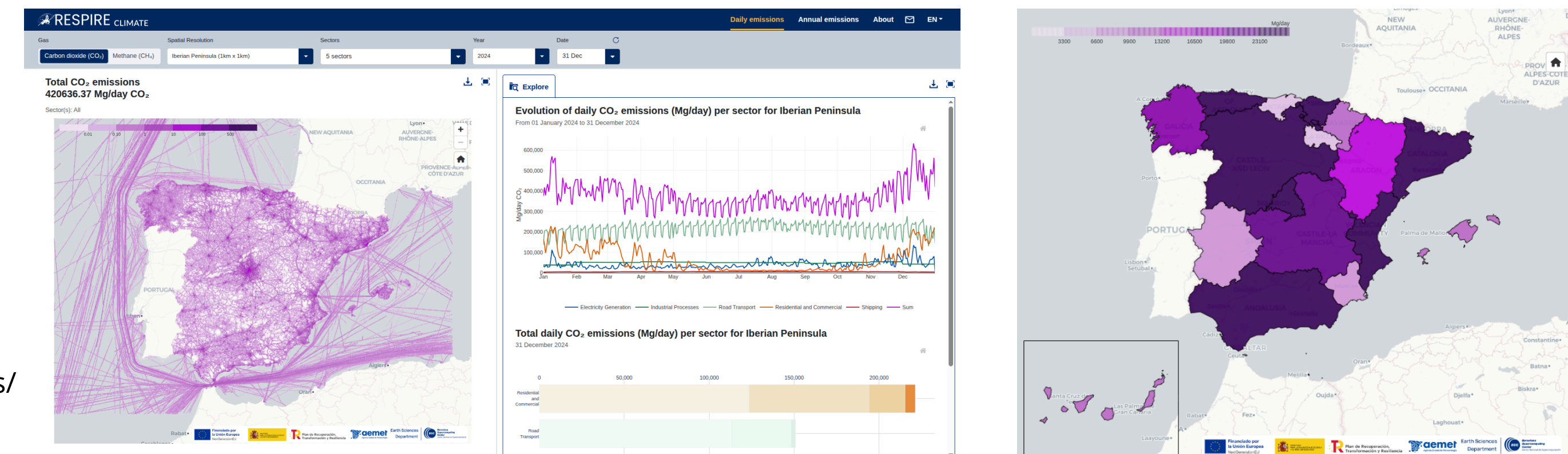
All modules can then be automated through the **Autosubmit workflow manager**, which allows running the components for a desired date in a more automated way.



Summaries

PHENOMENA is designed to produce emissions data for an **open web portal**, where users can navigate and access **daily low-latency GHG emissions data for Spain** in an accessible way, disaggregated by sector, gas, subsector, and administrative region.

This module is responsible for **standardizing, aggregating and formatting** the calculation outputs to prepare them for the website's dashboard.



RESPIRE-CLIMATE is recognized internationally by IG3IS (WMO initiative)



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