



RESPIRE



RESPIRE: high-Resolution air Emissions Systems to support modelling and monitoring Efforts in Spain

Sector: Maritime transport – near-real-time modelling of shipping CH₄ emissions

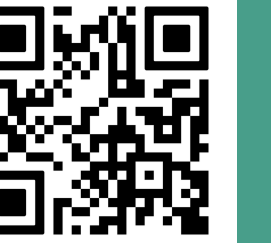
Iván Lombardich¹, Paula Castesana^{1,2}, Marc Guevara¹, Omaira García², Carles Tena¹, Angie Albarracín¹, Francesco Benincasa¹, Paula Camps¹, Oscar Collado¹, Antonia Frangeskou¹, Alejandro García¹, Johanna Gehlen¹, Oliver Legarreta¹, Francesca Macchia¹, Karinna Matozinhos¹, Calum Meikle¹, Miriam Olid¹, Carmen Piñero¹, Elliot Rose¹, Eliezer Sepúlveda², Noémie Taquet², Diana Urquiza¹, Alba Vilanova¹, Artur Viñas¹, Oriol Jorba¹, Carlos Pérez García-Pando^{1,3}

¹ Barcelona Supercomputing Center, Barcelona; ² Izaña Atmospheric Research Center (IARC-AEMET), Santa Cruz de Tenerife; ³ ICREA, Catalan Institution for Research and Advanced Studies, Barcelona, Spain.

RESPIRE aims to enhance Spain's capabilities for modelling atmospheric pollutants and monitoring greenhouse gas (GHG) emissions. Within RESPIRE-CLIMATE, a national system is being developed to quantify CO₂ and CH₄ emissions by combining activity-based and observation-based approaches. All geo-referenced and tabular outputs are then made publicly available through a dedicated web application for visualization and data access.

In RESPIRE-CLIMATE, Shipping emissions are estimated using high-resolution ship tracking data, providing near-real-time estimates of CO₂ and CH₄. LNG-fuelled ships are the main drivers of CH₄ emissions, and the model developed captures engine- and operation-dependent CH₄ slip, allowing to identify emission patterns and hotspots, and how they evolve over time.

RESPIRE CLIMATE



FOUR PILLARS INTEGRATING ACTIVITY-BASED AND OBSERVATION-BASED HIGH-RESOLUTION CO₂ AND CH₄ EMISSIONS

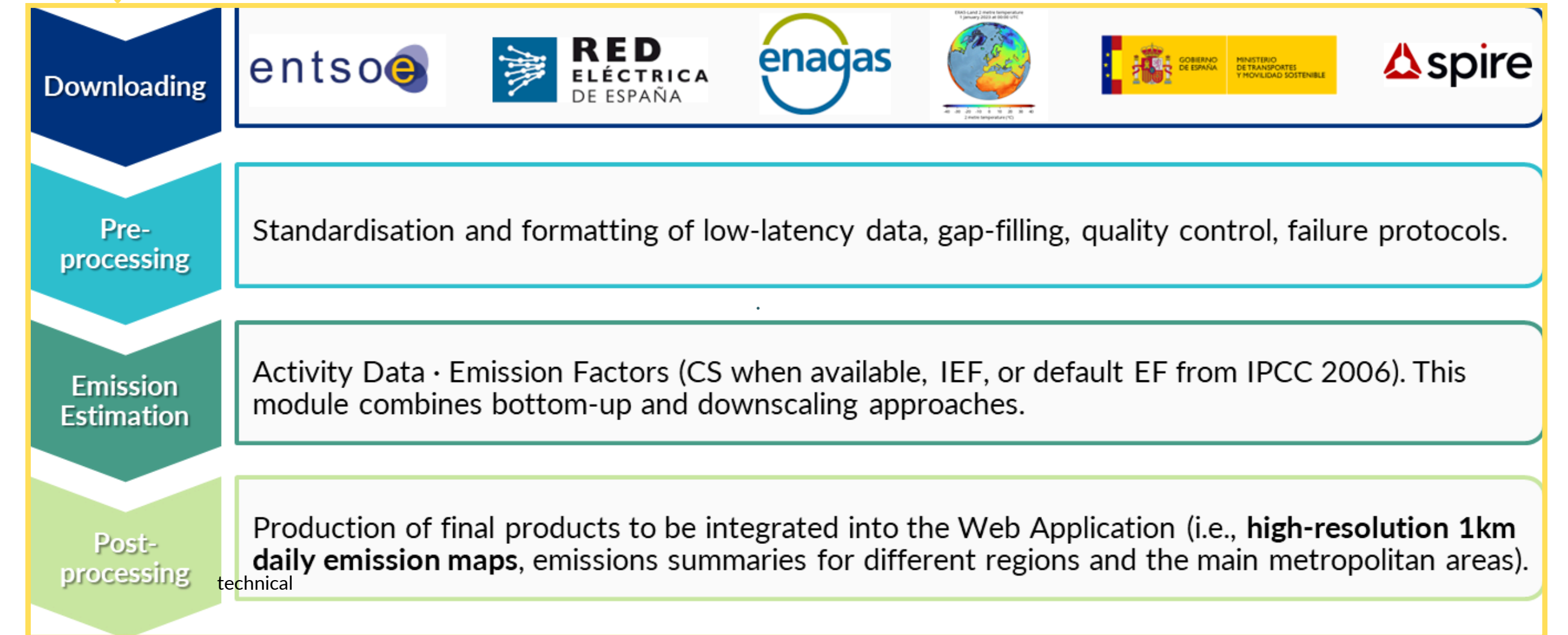
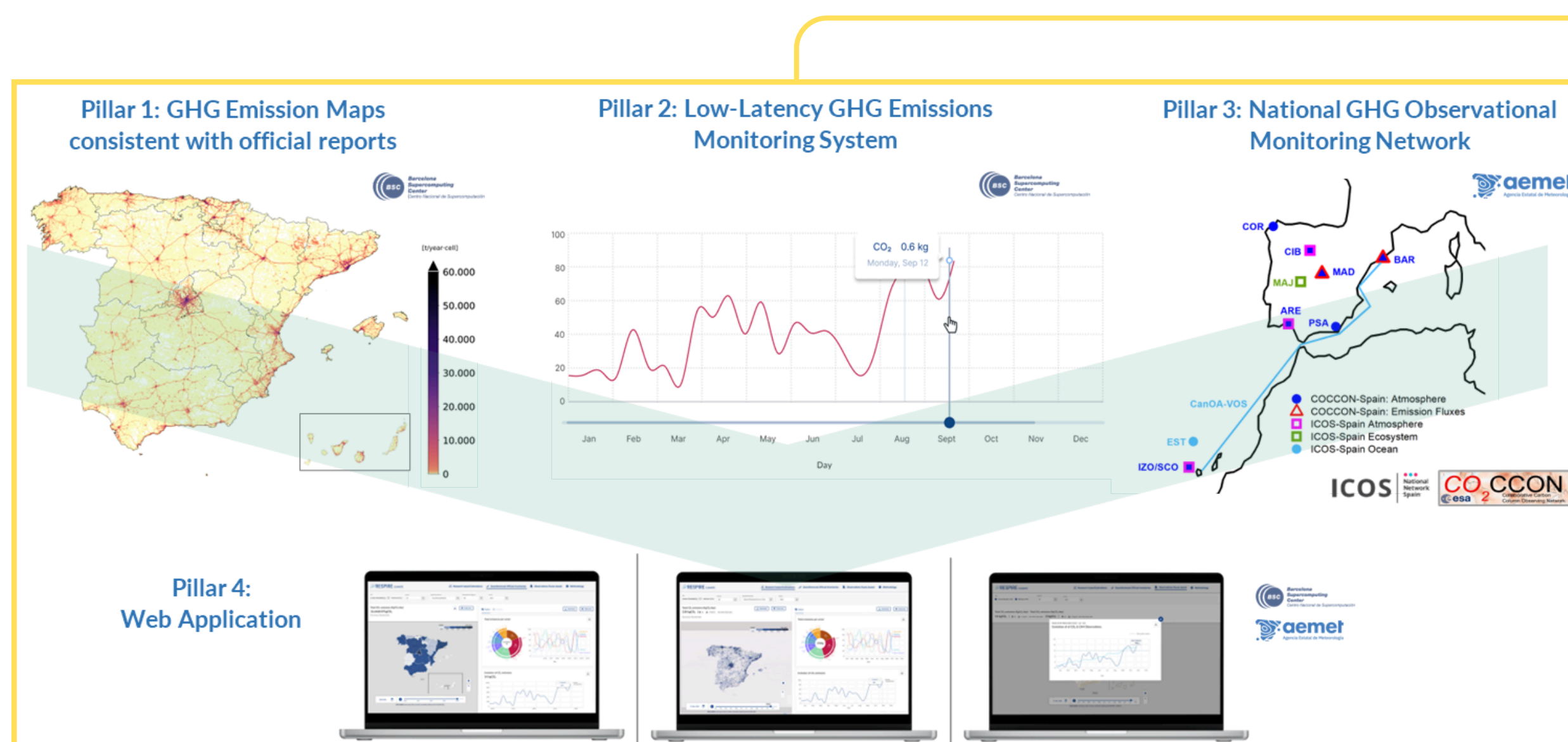
- Meeting diverse needs of policymakers, scientific communities, industries, and the public by providing comprehensive, high-resolution GHG emissions data.
- Creating tools and methods that offer useful insights needed for effective emissions inventories and strategies to meet Nationally Determined Contributions (NDC) targets.
- Facilitating data-driven decisions for emissions reductions across different scales.
- Contributing to identifying co-benefits and trade-offs with air quality.



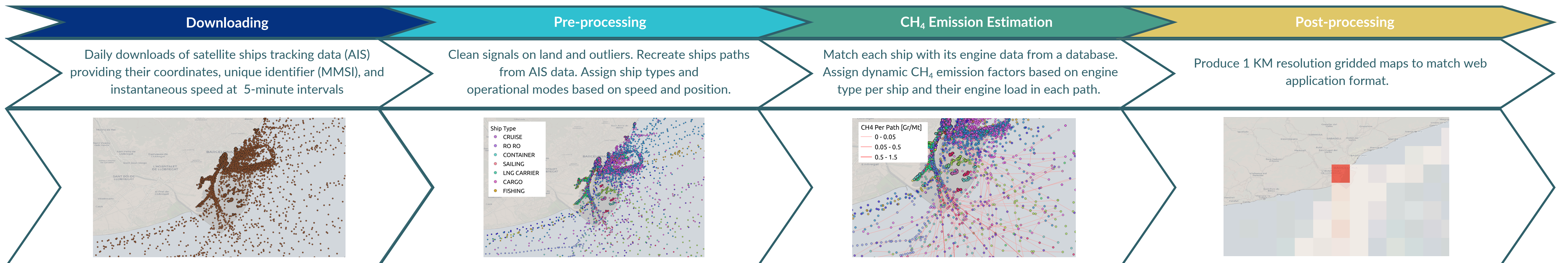
PILLAR 2: LOW LATENCY GHG EMISSIONS MONITORING SYSTEM (delay up to 3 months)

PHENOMENA: sPanish Emission mOnitoring systeM for grEeNhouse gAses

- Species:
 - CO₂, CH₄
- Sectors:
 - Electricity Generation, Industrial Processes (Cement, Iron&Steel), Residential and Commercial, Fugitives, Road Transport, Shipping, Aviation.
- Python-based, open-source system made up of four main modules.



MARITIME TRANSPORT CH₄ EMISSION MODELLING

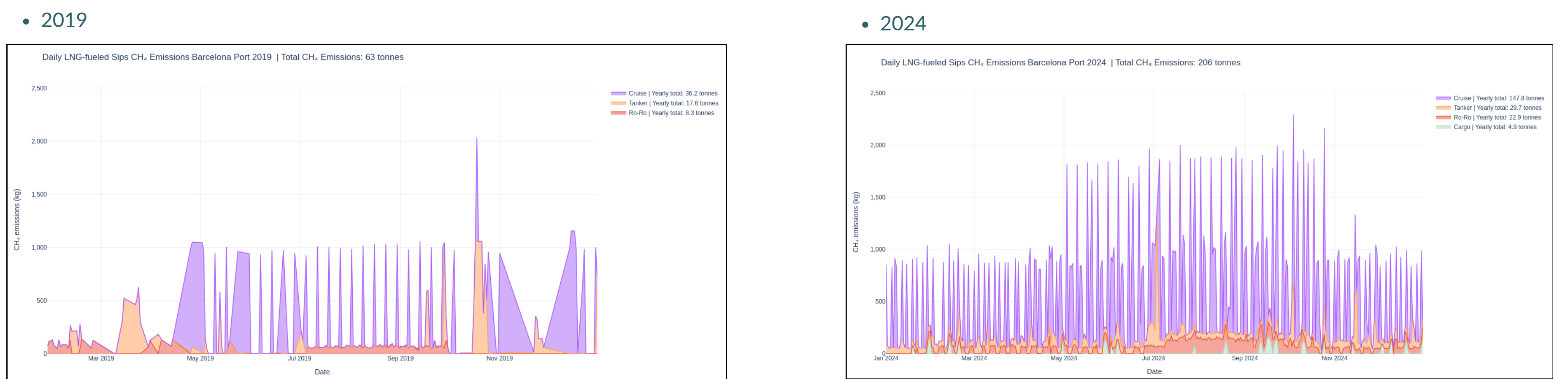


CH₄ EMISSION RESULTS IN BARCELONA PORT

LNG Transition in Spain's Maritime Sector

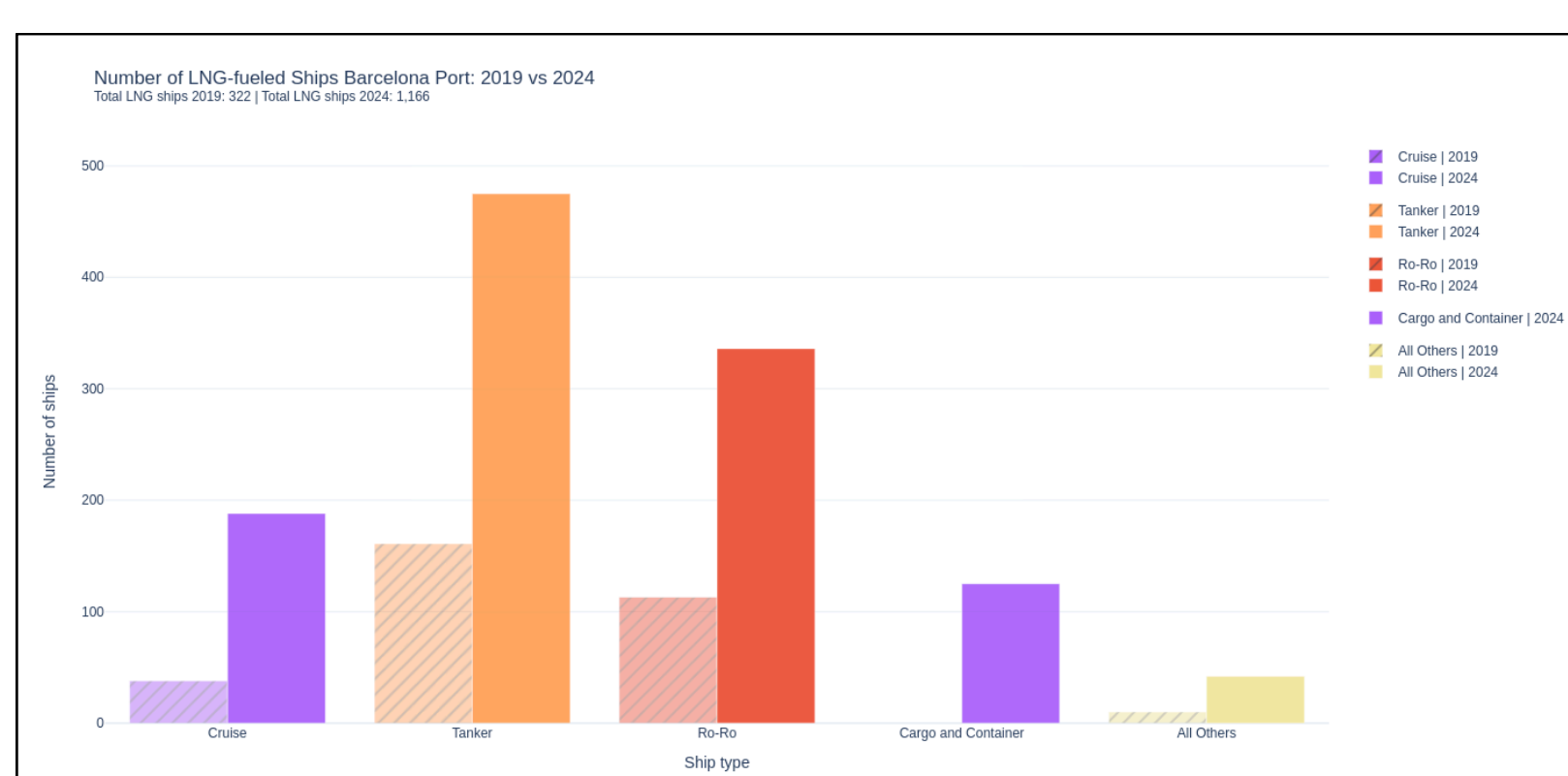
- After 2022, LNG imports into Spain increased by roughly 20% compared to 2019 levels, consolidating its role as a key entry point for Europe.
- In Barcelona, this shift did not translate into higher LNG import activity, but into an increase of LNG-fueled cruise and ferry traffic. This led to the deployment of dedicated bunkering infrastructure after 2021. Because of this, bunkering, that refers to the refuelling of ships with LNG, increased almost six times, from ~37,500 m³ in 2019 to ~230,000 m³ in 2024.
- The trends in Barcelona mirror a global expansion of LNG-fuelled fleets, in part due to regulatory pressure to reduce sulphur emissions such as the 2025 IMO Mediterranean Low Emissions Area.

Daily annual CH₄ emissions (kg/day) by ship type

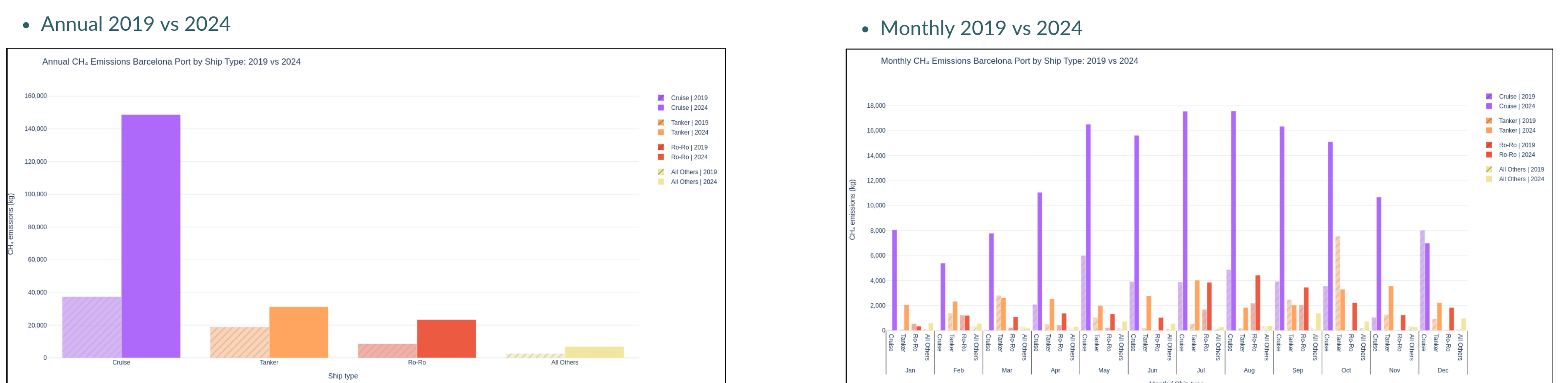


LNG-fueled ships per month

Barcelona Port - 2019 vs 2024



Accumulated CH₄ emissions (kg/day) by ship type - 2019 vs 2024



- The expansion of LNG bunkering and LNG-fuelled fleets is clearly reflected in higher CH₄ emissions in Barcelona, with LNG cruise ship activity rising from 38 vessels in 2019 to 188 in 2024, making cruise ships the main driver of this increase.
- Emissions show a strong seasonal pattern linked to cruise traffic peaks in summer, while LNG tanker ships contribute a stable, year-round baseline of CH₄ emissions due to their relatively constant activity.

The project is part of the Recovery, Transformation and Resilience Plan (Plan de Recuperación, Transformación y Resiliencia, PRTR) funded by the European Union – NextGenerationEU.

P. Castesana acknowledges her AI4S fellowship within the "Generación D" initiative by Red.es, Ministerio para la Transformación Digital y de la Función Pública, for talent attraction (CO05/24-ED CV1), funded by NextGenerationEU through PRTR.

