# Interreg Sudoe e-Rigation Project: The Contribution of Euskalmet

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## Abstract

This contribution presents an overview of the e-Rigation project objectives and activities, with emphasis on the role of Basque Meteorology Agency (Euskalmet), which leads Work Package 1 on the design and development of the virtual meteorological station system. This includes system requirements definition, implementation and calibration of tools for analysis and prediction, and the improvement of applications for irrigation water management. Euskalmet also contributes to implementation phase by integrating virtual station data into irrigation management tools and participating in pilot testing and evaluation.

These actions aim to ensure the operational delivery of daily agrometeorological indicators at parcel scale and to assess the technical and economic viability of the proposed solution. Key activities include the development of advanced interpolation and downscaling techniques to generate high-resolution meteorological fields; integration of observational data, numerical weather prediction outputs, and remote sensing products; generation of key irrigation variables such as reference evapotranspiration and soil water balance indicators; and adaptation of decision-support tools to incorporate virtual station data.

## 1.Introduction

Over the past decade, the Sudoe region (Spain, Portugal, and France) has faced increasing pressure on water resources due to climate change, recurrent droughts, and growing agricultural demand. These challenges highlight the need for more efficient irrigation practices and improved access to high-resolution agrometeorological information.

In many areas, the limited density of meteorological observation networks constrains the provision of accurate, parcel-scale data required for optimized water management. To address this issue, the e-Rigation project proposes an innovative solution based on virtual meteorological stations.

The initiative aims to generate operational, high-resolution meteo-climatic indicators at ground level, enabling more precise irrigation scheduling and supporting sustainable water resource management.

The project brings together a multidisciplinary consortium from across the Sudoe area, including research institutes, meteorological agencies and agricultural organizations and authorities. Basque partners play a key role, with Neiker as project coordinator and Basque Meteorology Agency (Euskalmet) contributing expertise in meteorological data analysis, modeling, and operational services.

The project is structured around three main pillars: (1) development of the virtual station system, (2) its implementation and validation through pilot experiences, and (3) knowledge transfer and capacity building among end users.

The project also emphasizes user engagement through training, dissemination, and knowledge transfer. Euskalmet contributes to training materials, supports pilot users, and participates in system performance evaluation and impact assessment on water efficiency and agricultural practices.

Overall, the e-Rigation project aims to advance smarter and more sustainable irrigation management in the Sudoe region through innovative meteorological services and collaboration between scientific, technical, and agricultural communities.

## 2. Methodology and Work Plan

The methodological approach adopted by Euskalmet within the e-Rigation project is based on the development, implementation, and validation of a virtual meteorological station system designed to provide high-resolution agrometeorological information at parcel scale. This approach is structured according to the project work plan, combining system development, operational deployment and user-oriented validation.

### 2.1. Design of the virtual meteorological station system

Euskalmet leads the design and development of the virtual station system, which constitutes the core of the system. The methodology is based on the integration of multiple data sources, including ground-based observations, numerical weather prediction outputs, and remote sensing products.

The first step consists of a detailed characterization of the pilot areas and the specific user requirements, identifying key variables, spatial scales, and temporal resolutions needed for irrigation management. Based on this analysis, a set of methodologies for spatial interpolation and downscaling is implemented to generate continuous spatial and temporal meteorological fields.

These methods allow the estimation of essential variables such as temperature, precipitation, radiation, wind, and derived indicators like reference evapotranspiration. The system is designed to operate in near real-time, ensuring the regular provision of updated information adapted to agricultural decision-making processes.

### 2.2. System implementation and integration into irrigation tools

Once developed, the virtual station system is integrated into existing irrigation management applications. This phase focuses on ensuring interoperability, data flow automation, and the operational delivery of daily agrometeorological indicators at parcel level for each pilot site.

Euskalmet contributes to data flow, optimizing frequency, and accessibility of the generated data, facilitating its use by decision-support systems in house of each partner. Particular attention is given to the adaptation of outputs to end-user needs, including farmers, technicians, and water managers.

### 2.3. Pilot testing and system evaluation

The developed system is tested in pilot areas representing different agricultural and climatic conditions within the Sudoe region. These pilot experiences allow the evaluation of the technical performance of the virtual stations, as well as their added value compared to conventional approaches.

The assessment includes the analysis of the accuracy of the generated variables, their impact on irrigation recommendations, and the overall improvement in water use efficiency. In addition, economic aspects related to the implementation and operation of the system are considered.

### 2.4. User engagement and knowledge transfer

A key component of the project is the active involvement of end users throughout the process. Training activities, field visits, and dissemination actions are carried out to facilitate the adoption of the developed tools.

Feedback from users is incorporated into the iterative improvement of the system, ensuring that the final solution is both technically robust and practically relevant.

This participatory approach supports the transferability and scalability of the virtual meteorological station concept across the Sudoe region.

## 3. Expected and Preliminary Results

The e-Rigation project is expected to deliver significant advances in the generation and application of high-resolution agrometeorological information for irrigation management in the pilot sites. From the perspective of Euskalmet, the main outcomes are associated with the development of an operational virtual meteorological station system and its validation under real agricultural conditions in different places.

**At the current stage of the project** results are mainly related to the initial setup and methodological development of the system. The first phase of the project focused on characterising agroclimatic regions, identifying observational and forecasting data sources, defining operational requirements and establishing methodological protocols. Particular effort was devoted to documenting observational networks, metadata management, quality control procedures and the integration of Earth Observation products.

### Multi-Source Data Strategy

The framework integrates national and regional meteorological networks, agrometeorological stations, satellite products and numerical forecasts. A configuration-driven approach based on YAML (Amstutz et al 2016, Inau et al. 2021) descriptions allows heterogeneous datasets to be transformed into a common operational format while maintaining traceability and reproducibility.

### Observational Data Harmonisation

A generic preprocessing layer was designed to harmonise different temporal resolutions, units, naming conventions and metadata structures. The system generates standardised hourly and daily products suitable for subsequent spatial modelling.

### Earth Observation Integration

The EO component combines geostationary and radar-derived products to capture complementary meteorological processes. LSASAF datasets provide information on land surface temperature, radiation and surface energy exchanges, while OPERA NIMBUS rainfall accumulation products contribute spatially distributed precipitation estimates. After regional clipping, reprojection and alignment to a common DEM-based grid, these datasets are incorporated as operational covariates within the virtual weather station framework and subsequent spatial modelling workflows.

### Territorial Integration

After harmonisation, observational products are merged by study area. The territorial layer introduces common coordinate systems, DEM-based spatial filtering and preparation for subsequent spatial estimation methodologies.

### Modelling Framework

The downstream framework is being prepared for high-resolution spatial prediction through the Ensemble Machine Learning for spatial prediction - EML4SP system (Hengl et al. 2018, 2019). Current work focuses primarily on data infrastructure and methodological foundations, while advanced ensemble machine learning products remain under validation.

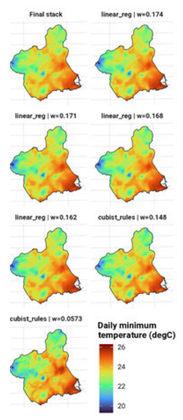


Figure 1. Example of a preliminary result. The panel illustrates the final combined prediction model (Final stack) along with the selected base members (retained ensemble members) sorted by their assigned weights. The comparison features multiple linear regression (linear_reg) and rule-based Cubist (cubist_rules) models. The color scale indicates the predicted daily minimum temperature values in degrees Celsius (°C).

**In the next phases**

We aim to implement the system an to demonstrate its capability of the to provide reliable operational daily estimates of relevant variables, such as temperature, precipitation, and reference evapotranspiration, at the parcel scale.

The integration of these data into irrigation management tools will allow assessing their practical impact on decision-making processes. In particular, improvements are anticipated in terms of water efficiency, reduction of unnecessary irrigation, and better adaptation to climate variability.

Pilot experiences will provide key insights into the technical performance and robustness of the system under different environmental and agricultural conditions. In addition, the evaluation will include an analysis of the economic feasibility of the proposed solution, considering both implementation and operational aspects.

Finally, user feedback collected during the project will help to refine the system and ensure its usability and acceptance. Overall, the expected results point towards a scalable and transferable solution that bridges the gap between meteorological information and efficient irrigation practices in the Sudoe region.

## 4. Remarks and conclusions

- ✓ The e-Rigation project represents a step forward in the application of advanced meteorological services to support efficient irrigation management in the Sudoe region.
- ✓ By leveraging the concept of virtual meteorological stations, the project addresses the limitations of sparse observation networks and enables the provision of high-resolution agrometeorological information at parcel scale.
- ✓ Euskalmet's contribution is focused on the development of robust methodologies for generating and integrating meteorological data from multiple sources, ensuring their operational applicability. This approach facilitates the derivation of key variables for irrigation management and supports their incorporation into decision-making tools used by farmers and water managers.
- ✓ The expected outcomes highlight the potential of the system to improve water use efficiency, enhance the adaptation of agricultural practices to climate variability, and promote more sustainable resource management. In addition, the validation of the system through pilot experiences and user engagement activities will be essential to ensure its reliability, usability, and transferability.
- ✓ Overall, the project contributes to bridging the gap between meteorological science and agricultural applications, fostering innovation in irrigation practices and supporting the transition towards more resilient and sustainable agro-systems in the Sudoe region
- ✓ Participation in the e-Rigation project will allow us to collaborate and learn from similar experiences in the Sudoe area.
- ✓ This project has been underway since mid 2025 and will conclude at the end of 2028.

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## e-Rigation

The e-Rigation project is a collaborative initiative aimed at enhancing irrigation optimization across the South-Western European (Sudoe) region, encompassing Spain, Portugal, and France. It addresses the escalating threat of reduce the impact of agricultural activities on the water system and promote adaptation to a context of progressive water scarcity in Sudoe area.

### Project Overview

e-Rigation seeks to develop and implement innovative strategies through a three-phase approach:

**1. Design and Creation:** Conducting characterization studies and implementing analysis and prediction systems based on virtual stations.

**2. Implementation and Testing:** Integrating data into applications and piloting optimized irrigation tools in participating territories.

**3. Training and Transfer:** Disseminating results through capacity-building for producers and exchanging experiences across the region

The project emphasizes the importance of understanding local conditions and demonstrating the effectiveness of innovative tools in situ, ensuring their adaptability and transferability to other areas facing similar challenges,

### Main Objective

To develop and test an innovative, efficient irrigation approach based on networks of virtual weather stations to reduce the impact of agricultural activities on the water system of the Sudoe area and promote adaptation to progressive water scarcity and climate change.

### Specific Objectives

1. To design and develop an innovative, efficient irrigation solution through virtual weather stations that operationally provides various meteo-climatic indicators at the plot level across different Sudoe areas, enabling its subsequent integration into existing irrigation management systems.
2. To integrate, pilot-test, and evaluate (both technically and economically) the innovative, efficient irrigation solution based on virtual weather stations, ensuring the daily flow of data and indicators at the plot level to optimize monitoring applications.
3. To raise awareness, explain, and train the agricultural productive sector, farmers, and water resource managers for the successful uptake, assimilation, and institutional integration of the developed innovative irrigation solutions.

### Timeline and Funding

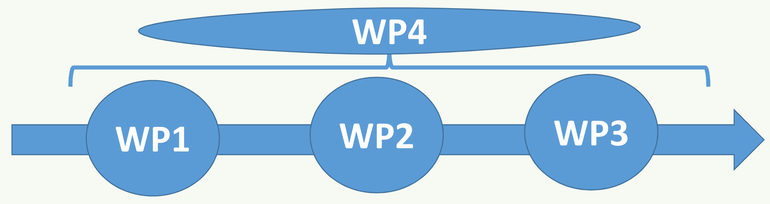
- **Duration**: June 1, 2025 – December 31, 2028
- **Total Eligible Cost**: €1.540.752
- **EU Funding (ERDF)**: €1.155.564

The project is co-financed by the European Regional Development Fund (ERDF) under the Sudoe Programme, which focuses on preserving natural capital and enhancing climate change adaptation in the Sudoe area.

### Consortium Partners

The project involves a diverse consortium of partners from Spain (Basque Country, Murcia), Portugal (Centro, Norte), and France (Nouvelle-Aquitaine) including: 1 - NEIKER-Instituto Vasco de Investigación y Desarrollo Agrario, S.A. 2 – Euskalmet, Agencia Vasca de Meteorología, S.A.; 3 - Instituto Murciano de Investigación y Desarrollo Agrario y Medioambiental; 4 - Association Climatologique de la Moyenne-Garonne et du Sud-Ouest; 5 - Chambre d'agriculture Dordogne; 6 - Chambre d'Agriculture des Pyrénées Atlantiques; 7 - Instituto Politécnico de Bragança, Escola Superior de Comunicação, Administração e Turismo; 8 - Comunidade Intermunicipal Viseu Dão Lafões; 9 - Comunidade Intermunicipal do Douro.

This collaborative effort aims to foster a unified approach to irrigation optimization across the Sudoe region, leveraging the expertise and resources of each partner to achieve shared objectives.




### Work Packages

**WP1. Design and creation of the virtual station system**

1. Pre-implementation characterization of the system
2. Implementation and fine-tuning of the analysis and prediction system based on virtual stations
3. Selection and improvement of water management applications in agriculture

**WP2. System implementation (pilot tests)**

1. Integration of virtual station data into irrigation and optimization applications
2. Pilot testing and evaluation of optimized applications using virtual weather stations
3. Audiovisual dossier for each pilot test
4. Economic feasibility analysis of the virtual station data supply system

**WP3. Training and exchange of experiences among system users**

1. Training and capacity-building program for producers
2. Efficiency report on the developed solutions and public policy guidance
3. Awareness-raising missions for public decision-makers and field visits
4. Final results presentation eventCross-cutting

**WP4. Management and coordination**

1. Periodic reporting
2. Risk management
3. Mid-term and final external project evaluation (IPB)

https://interreg-sudoe.eu/en/proyecto-interreg/e-rigation/

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