Digital Twins of Natural Resources in the Loire Valley

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Abstract

We present the design of a Digital Twin for the natural resources of the Loire Valley, one of the most emblematic natural environments in central Europe. A conceptual approach to the data architecture and component integration is shown by describing represented resources, data sources, use cases and functionalities. Such a holistic approach enables easier study, management, understanding and prediction of natural resources and their relationship with human activity.

Keywords

Digital Twins, Natural Resources, Environmental Science

1. Introduction

A Digital Twin (DT) is a digital representation of an unique entity that encompasses a set of features and behaviors by means of models and data [1]. The purpose of a DT is to improve the understanding of the real counterpart, monitor its state and predict its evolution, but also to test changes without affecting it [2]. DTs are promising for optimizing the use of natural resources, giving rise to initiatives such as the DestinE program [3]. However, the application of DTs for sustainability is still in its infancy [4], partially due to the lack of methodologies for their implementation [2]. The JUNON program[1] aims to build a DT of natural resources in the Loire Valley, France. Here we introduce the conceptual and methodological design of its prototype.

2. Methodology

The introduced DT is supported by an existing sensory base. Figure 1 shows its constituent parts with a focus on targeted resources, data sources, functional objects and built models, and a set of aimed use cases.

To satisfy interoperability and standardization, the DT architectural design is consistent with the Environmental Research Infrastructures Reference Model (ENVRI RM) [12]. From an operational perspective, the DT has two parts: (a) DT Front End with three layers: *visualization* (main dashboards and representative services), *applications* (collection of workflows and use-case applications), and *data*

[1]https://www.brgm.fr/en/programme/junon-digital-twins-working-natural-resources

* KB: Knowldge Base, hist.: historical, poll.: pollutants, prop.: properties, trans.: transportation, AQ: Air Quality, GHG: GreenHouse Gases (N_2O, CO_2, CH_4)
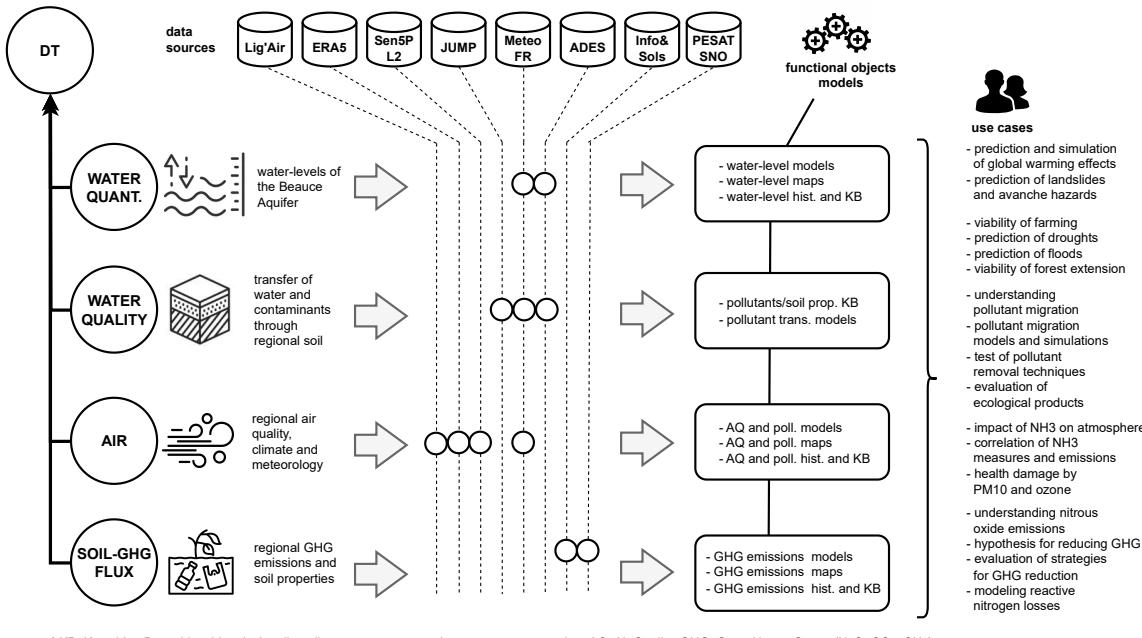
Figure 1: DT conceptual schema. Data sources: Lig'Air [5], Météo-France (MeteoFR) [6], ERA5 [7], Sentinel-5P L2 (Sen5P L2) [8], ADES [9], JUMP (BRGM), Info&Sols (INRAE, OS^2) [10], and PESAT (OSUC-Univ. Orléans) and SNO Tourbières [11].

(direct access to data resources); (b) DT Back End, composed by *face* (DT's core functionality, validated data and main services), *limbs* (access to raw data and non-essential services) and *back* (system updates). A proof of concept that emulates some parts of DT, data exchange protocols and communication processes is accessible through a doi-citable repository [13]. It shows analysis and visualization of multivariate time series of 255 measurement points in France by combining data from three different external sources (ERA5, ADES, Folium).

3. Conclusions

The development of digital twins of regional natural resources is key to achieve sustainability. Our conceptual design for the Loire Valley aims to be one of the earliest referents, also paving the way for creating proper digital frameworks for future AI-assisted Environmental research.

Acknowledgments

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