



RÉPUBLIQUE
FRANÇAISE

*Liberté
Égalité
Fraternité*

InfoGeol

Version 1.0



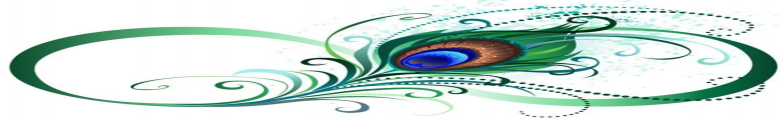
Géosciences pour une Terre durable

brgm

SEMANTIC STORYTELLING TO ENHANCE THE COMMUNICATIVE POWER OF DIGITAL TWIN

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09/03/2026



Presentation outline

- Introduction
- Problem statement
- Proposal approach
- Case Study
- Ontology for JUNON workflow
- Demo : POC
- Conclusion

Introduction



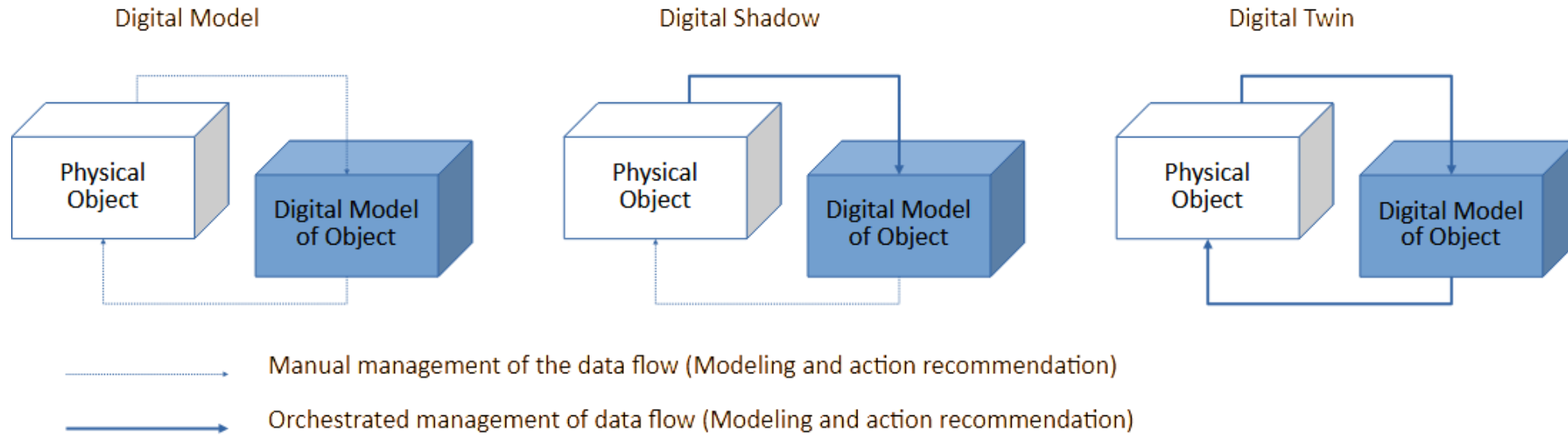
- A digital twin (DT) is a digital model of an intended or actual real-world physical product, system, or process (a physical twin) that serves as a digital counterpart of it for purposes such as simulation, integration, testing, monitoring, and maintenance. (Torbjørn et al, 2020) (Haag et al, 2018) (Boschert et al, 2016).
- The specific information contained in the digital twins is driven by use cases. The digital twin is a logical construct, meaning that the actual data and information may be contained in other applications.
- Several domains :
 - ✓ Manufacturing industry
 - ✓ Renewable energy industry
 - ✓ Urban planning and construction industry
 - ✓ Healthcare industry
 - ✓ **Environmental management**



JUNON



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Digital twin also has orchestrated data flow to improve recommendations of digital model each time they are applied to physical object.

Introduction

Funded by



A regional dynamic partnership



JUNON

The Beauce plain

Digital twins for the water, soil and air sectors for environmental management



Couvre plus de la moitié du territoire français.

Plaine de Beauce :
première région céréalière en France et en Europe.

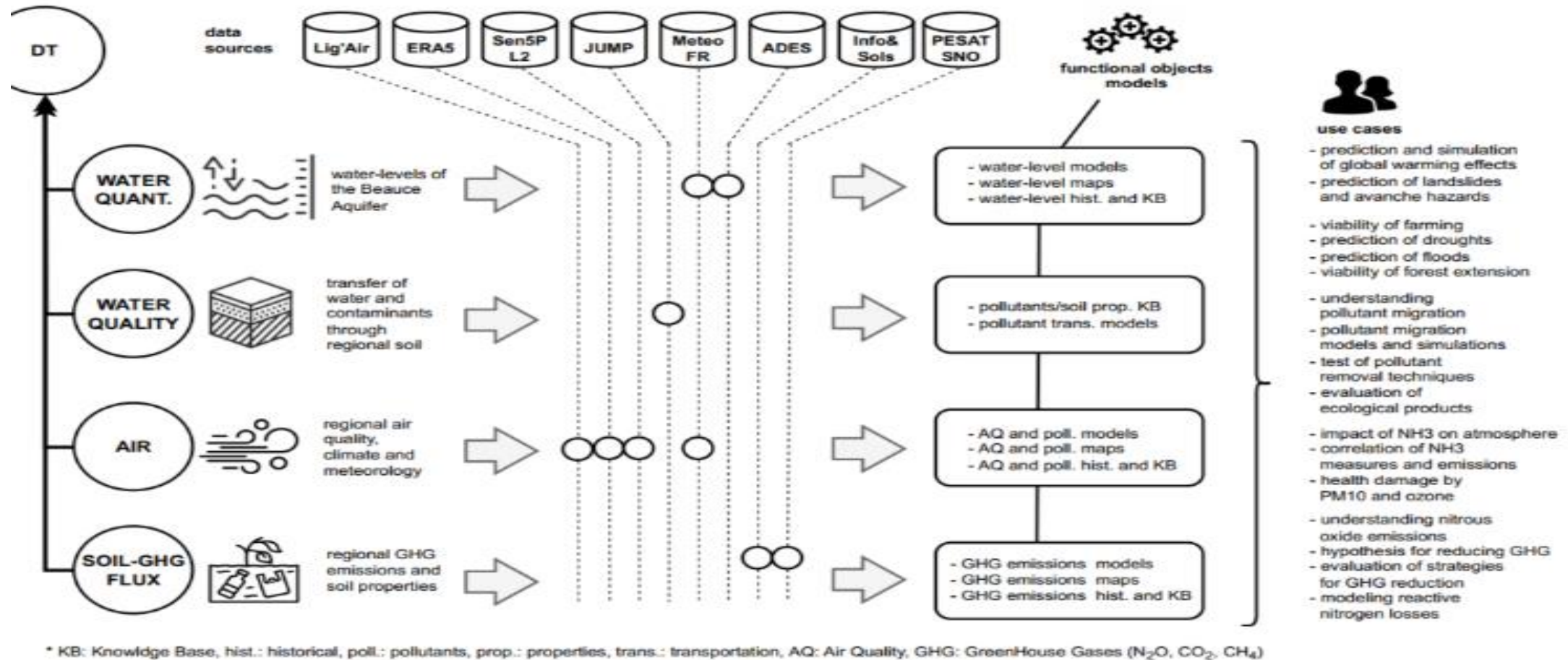


Paysages dominés par rivières, terres agricoles et forêts

Nappe phréatique de la Beauce : la plus grande d'Europe.

La Vallée de la Loire

Introduction



(Vázquez, F et al; 2024, 27th International Conference on Discovery Science 2024. October 14-16, 2024, Pisa, Italy)

Problem statement

X DT-proof v1.3

About

INPUTS

SHOW

Clustering x v

BSS POINTS

ANALYSIS OPTIONS

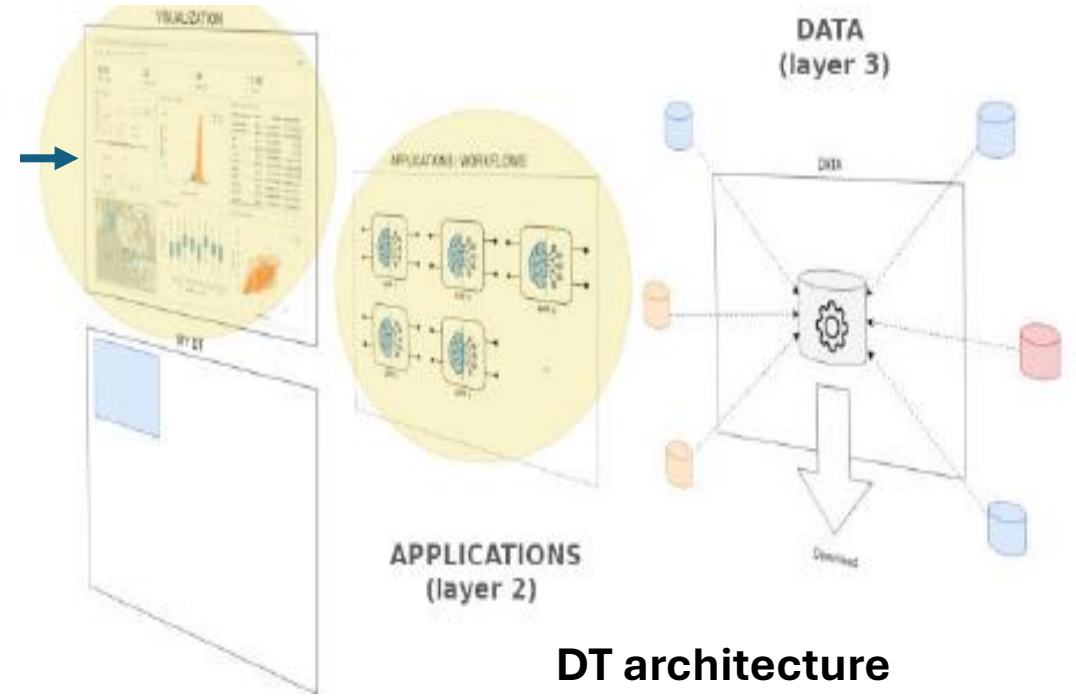
Seasonal dec. + SDOct. x v

Submit

DT-proof v1.3



**VISUALIZATION
(layer 1)**



DT architecture



Problem statement

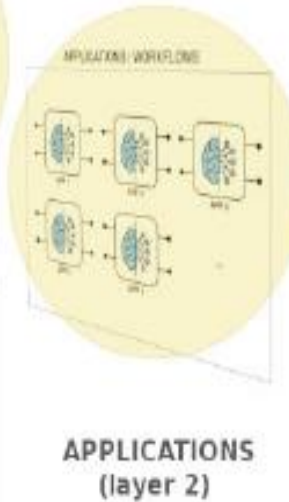
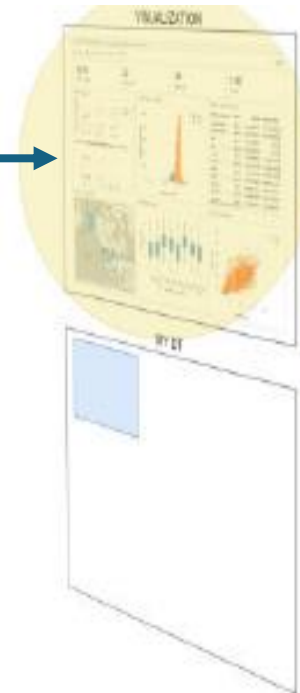
Different audiences



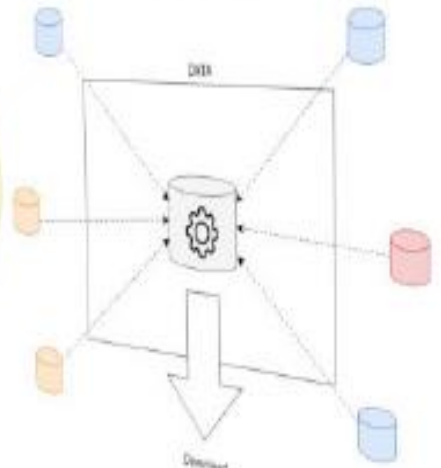
Different actions depending on the audiences goals

Generic dashboards and static charts

VISUALIZATION (layer 1)



DATA (layer 3)



DT architecture

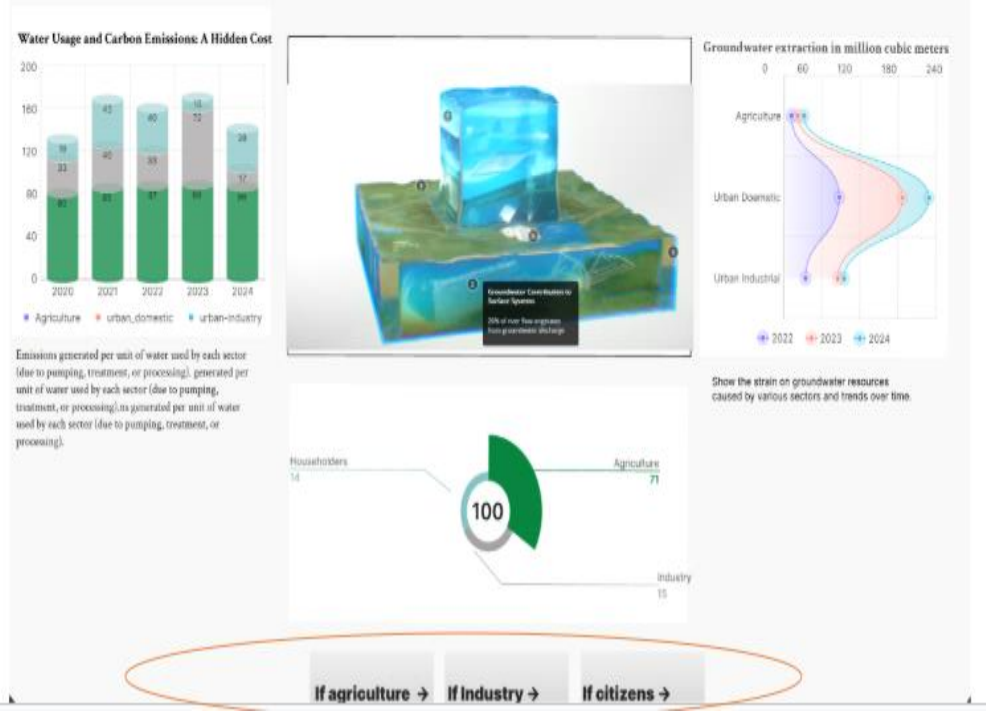
- Take on the consideration users needs and context.
- Non-expert can not understand scientific results
- Limit decision-making impact

Digital twins mimic data stories

It take many visual narratives forms: **Dashboard**

Competing Water Usage: Agriculture, Urban Citizens and Industry

This dashboard shows the competing water usage between agriculture and urban citizens and industrial. This dashboard includes a 3D model that shows the water cycle and its interaction with natural and human mode system. With access to historical data and trend analysis, it provides actionable insights to support sustainable and equitable water management decisions.



Proposal approach

Proposal approach

Behind digital twins,

Multidisciplinary Activities: From Data to Communication

Explore



Data exploration

From data collection until data analysis



Data visualization

For data analysis, virtual representation

Present

Answer questions



Decision making

Description, Diagnostic, prediction and prescription



Community Engagement

Various profiles, approaches and terms among community

Structure answers



Proposal approach

From narrative to data narrative

A **data narrative** is a **structured** composition of **messages** that

(a) convey **insights** over the **data**, and,

(b) are delivered via **visual means** to facilitate their reception by an intended audience.

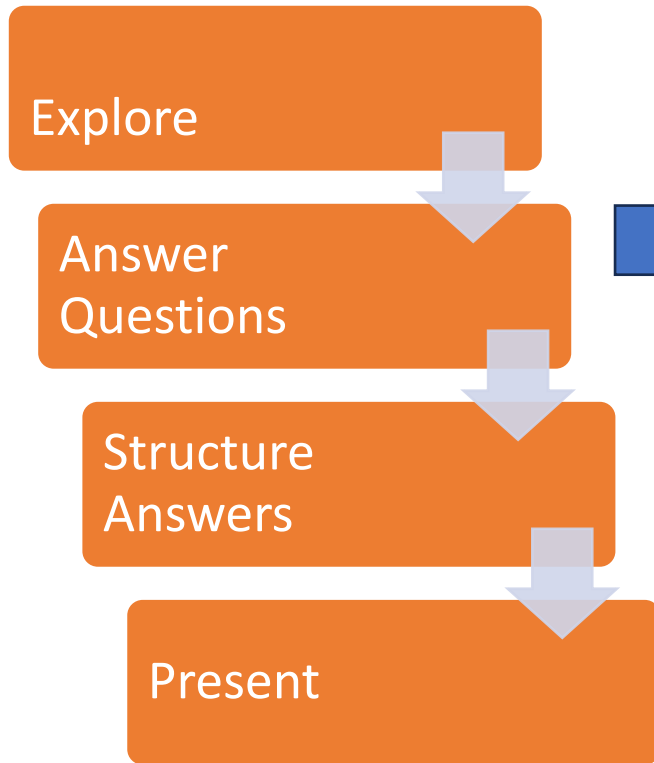
- 📖 D. Elson: "Modeling narrative discourse", Ph.D. thesis, Columbia University, 201
- 📖 S. Chatman: "Story and Discourse: Narrative Structure in Fiction and Film", Cori
- 📖 S. Chen, J. Li, G. Andrienko, N. Andrienko, Y. Wang, P. Nguyen, C. Turkay: "Suppr TVCG 2018.
- 📖 F. El Outa, M. Francia, P. Marcel, V. Peralta, P. Vassiliadis: "Towards a conceptua



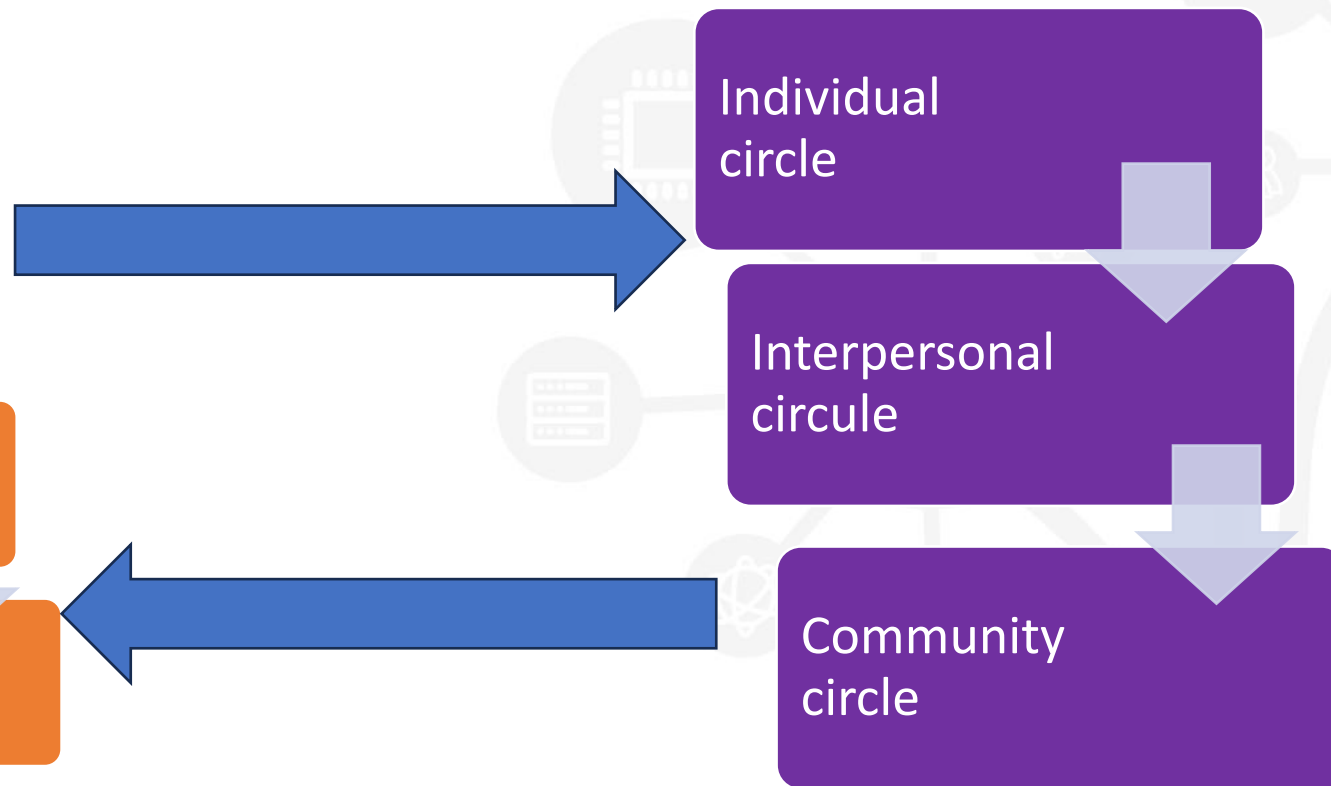
Proposal approach

- User centred workflow built around a four-phase data storytelling cycle [4,3]

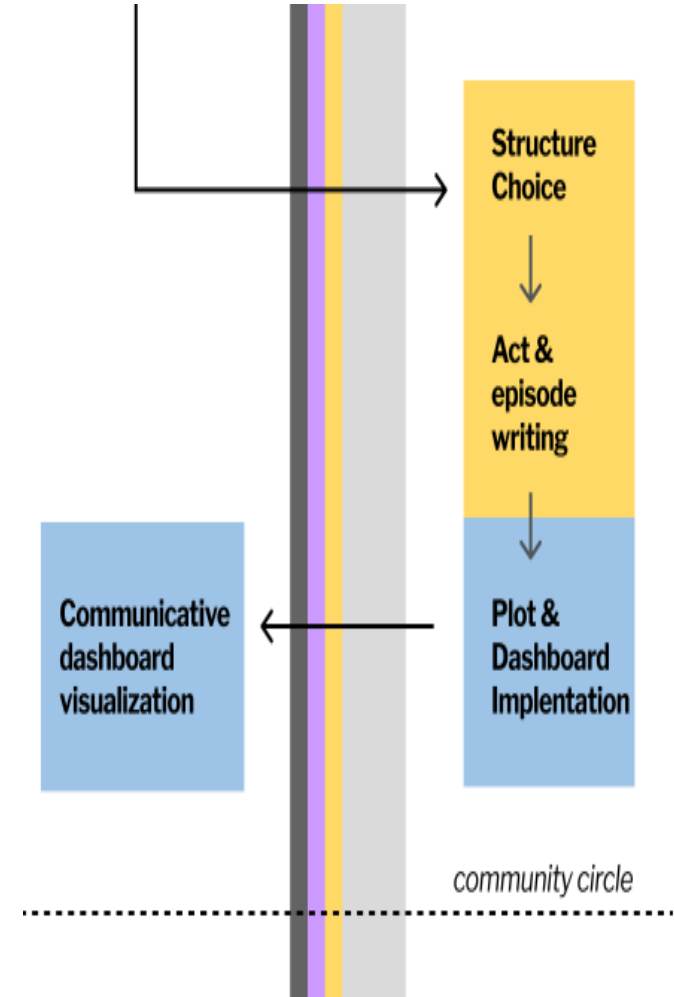
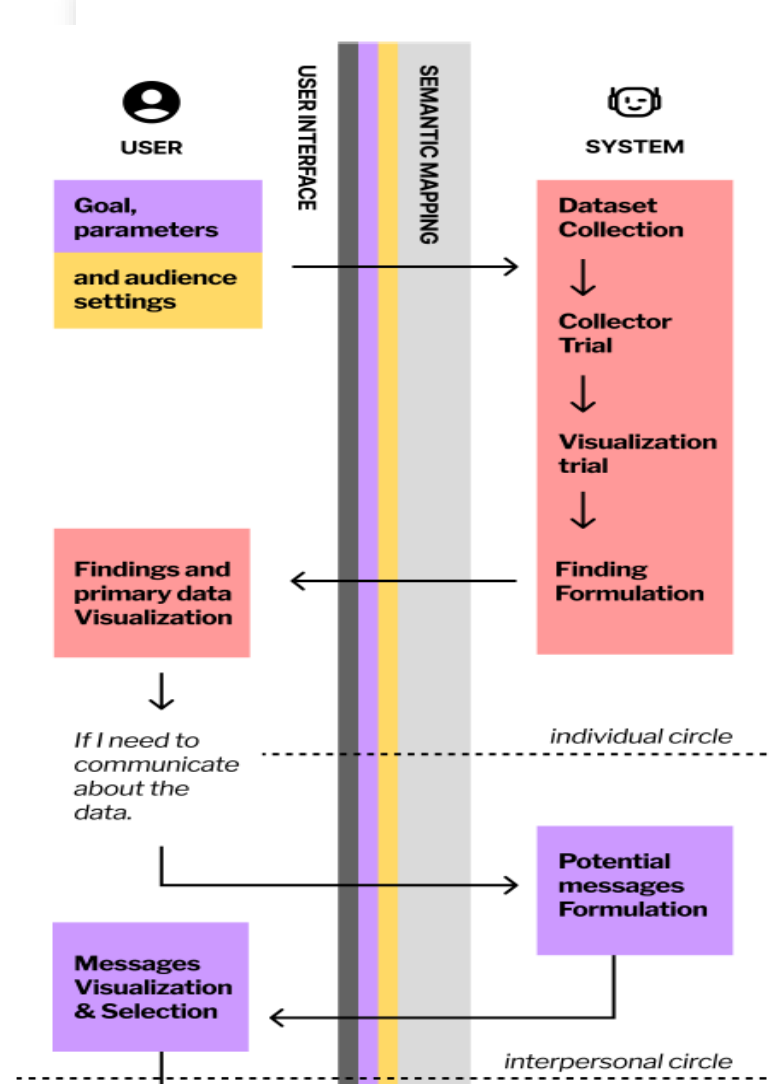
Four phases



Three formalisation level



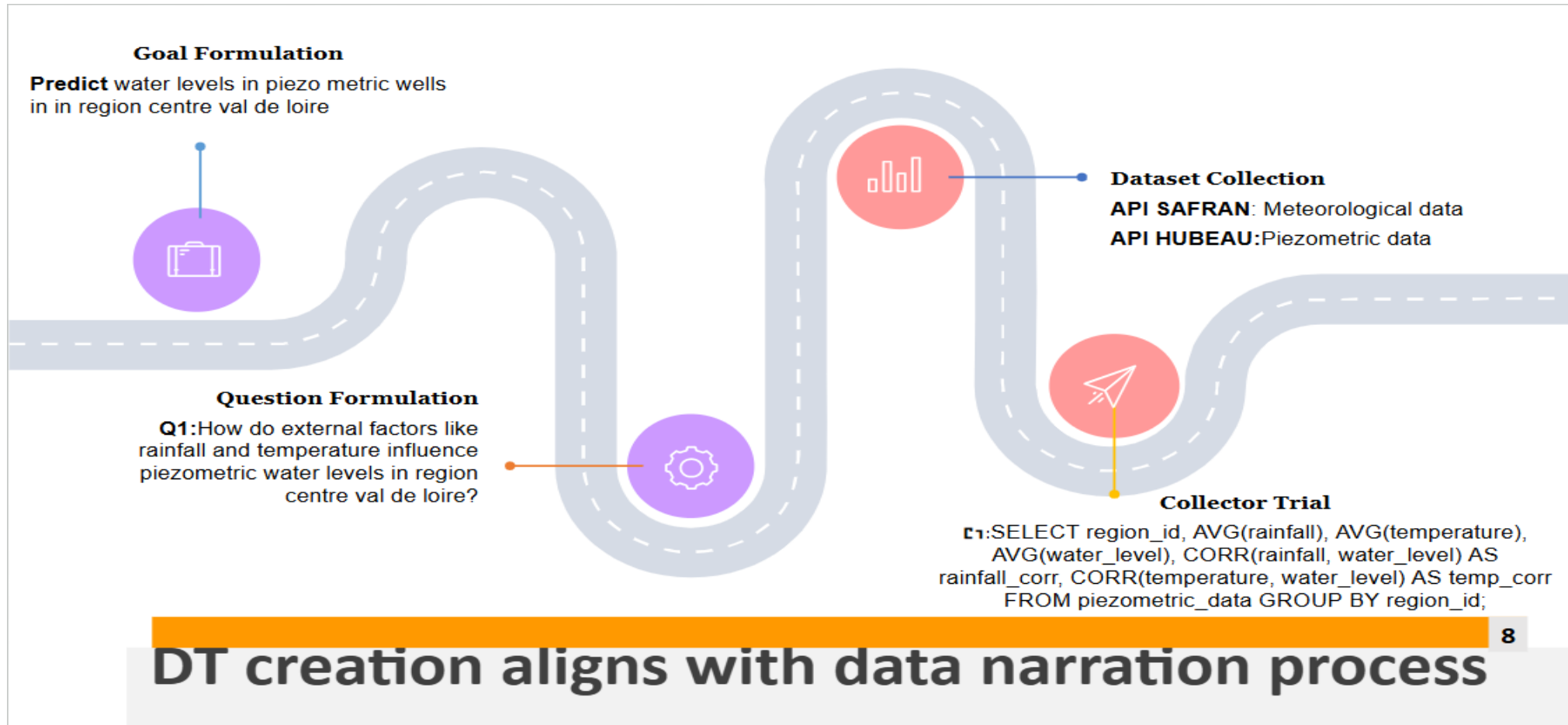
User-System Communication Workflow for Digital Twins



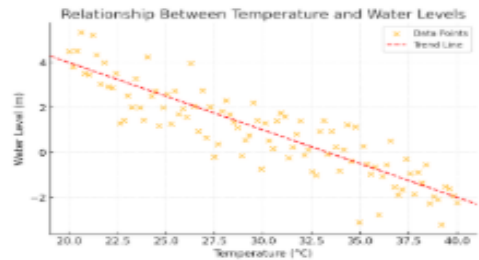
Case study : prediction groundwater levels

Element	Description
Intentional Operator	<i>Predict</i> — Used to anticipate environmental conditions and guide preventive actions.
Parameters	Groundwater Level, Location (Piezometer 03266X0009/P), Date (2019-01-01), Forecast Horizon (12 months).
Dataset	Historical time series: weekly groundwater levels, local rainfall, and evapotranspiration from past years.
Algorithm	Random Forest Regression — Applied to model complex, non-linear interactions between inputs (e.g., rainfall, evapotranspiration) and outputs (e.g., groundwater levels).
Type of Result	Numerical values — Predicted weekly groundwater levels for 2019 (in meters).
Narrative Pattern	Gradual Reveal + Call-to-Action — Forecast results are progressively unveiled to build audience engagement, followed by a clear directive. Example: “Week by week, groundwater levels have steadily dropped. By July, projections indicate values falling below 113.5 meters, the drought alert threshold. To prevent water shortages, initiate conservation efforts before the end of spring.”
Plot Structure	Water Tower — Begins with an impactful introduction and sequentially delivers accessible insights.
Visualization	Line Chart + Area Chart with Threshold Marker — Tracks changes over time and flags critical levels intuitively.

Case study : prediction groundwater levels



Case study : prediction groundwater levels



Q1:How do external factors like rainfall and temperature influence piezometric water levels in region centre val de loire?

Visualization Trial



Finding

F1: Positive correlation between rainfall and water levels in permeable areas (corr = 0.85).

F2: Negative correlation between high temperatures and water levels (corr = -0.65).



Finding validation

Statistical Significance Test: Pearson



Message formulation

M1: High rainfall and permeable soils lead to rapid recharge of aquifers,

M2: Low rainfall and high temperatures reduce recharge rates, causing water level declines.

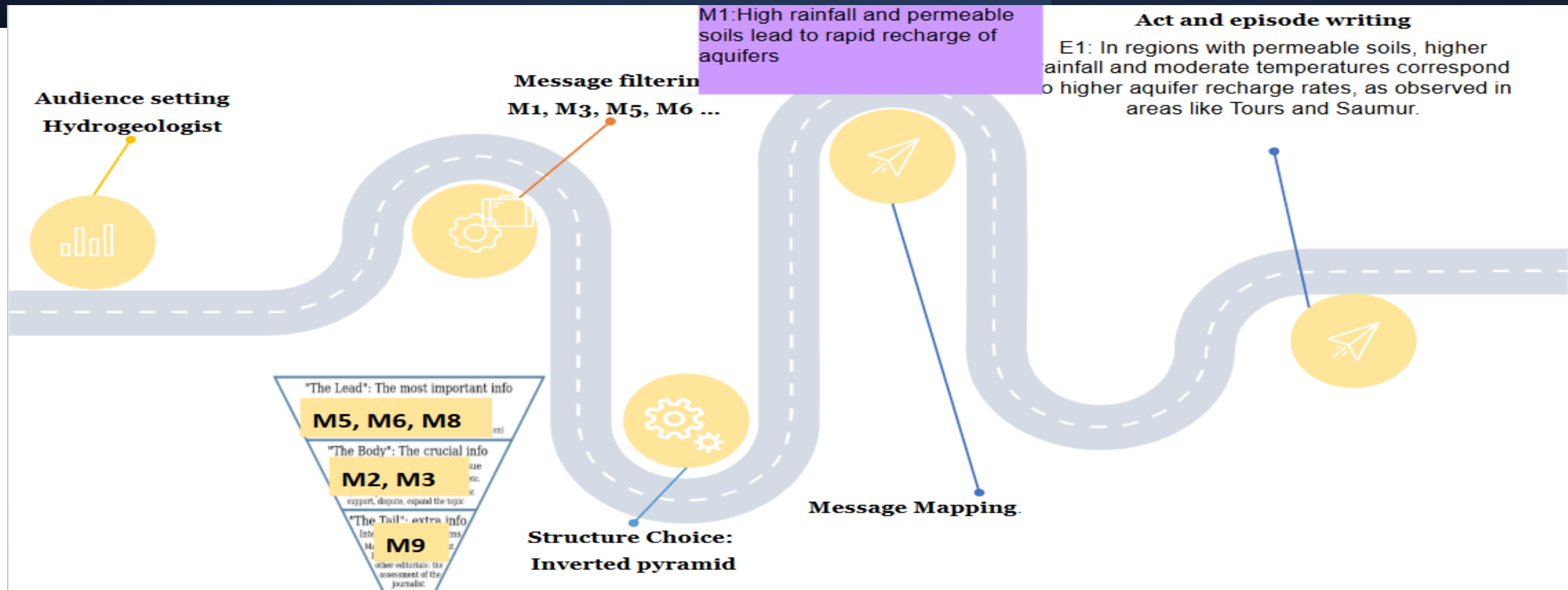


Message validation

Soil Scientists

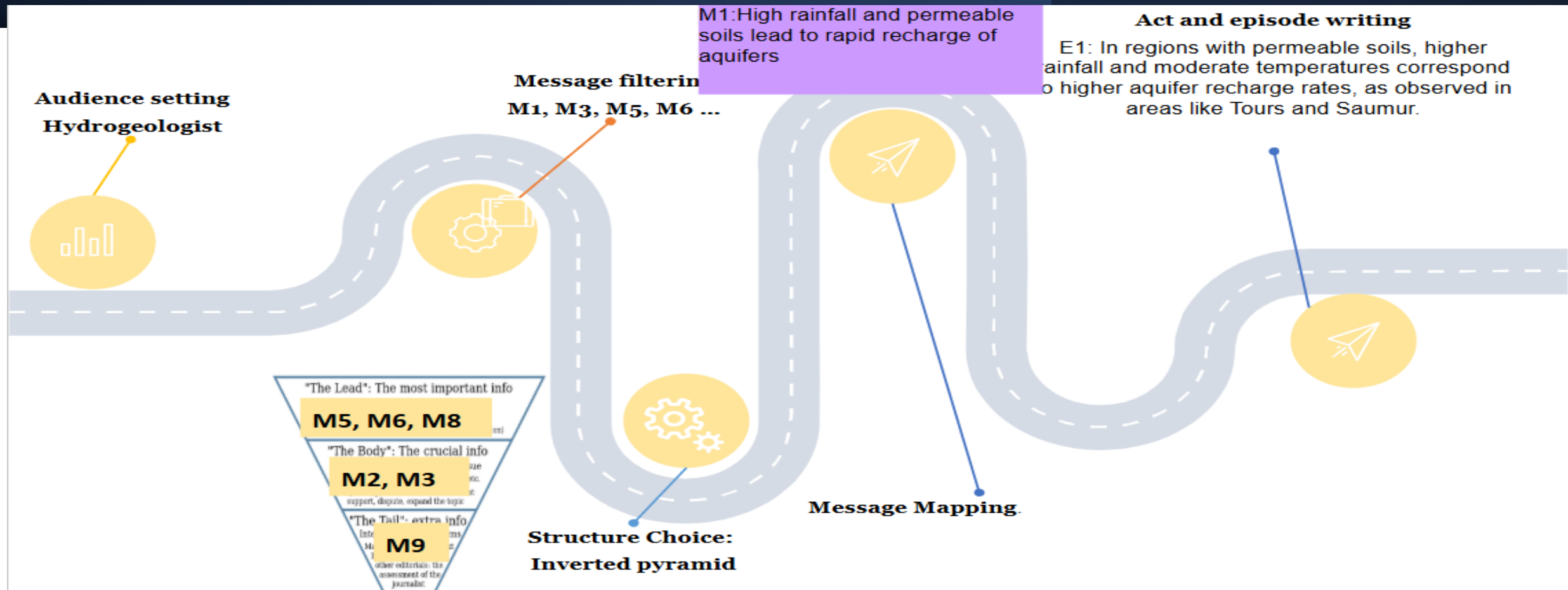
DT creation aligns with data narration process

Case study : prediction groundwater levels



DT creation aligns with data narration process

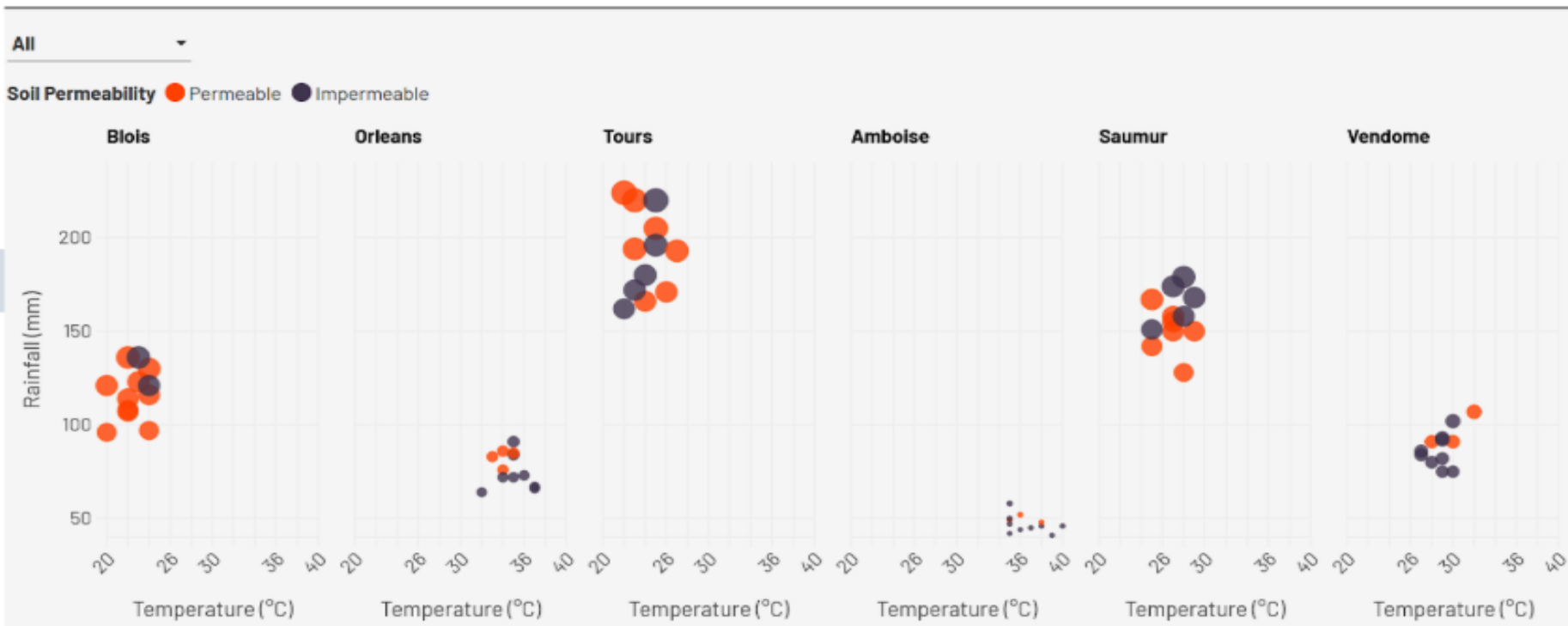
Case study : prediction groundwater levels



DT creation aligns with data narration process

Case study : prediction groundwater levels

1 of 1 In regions with permeable soils, higher rainfall and moderate temperatures correspond to higher aquifer recharge rates, as observed in areas like Tours and Saumur.



E1: In regions with permeable soils, higher rainfall and moderate temperatures correspond to higher aquifer recharge rates, as observed in areas like Tours and Saumur.

DT creation aligns with data narration process

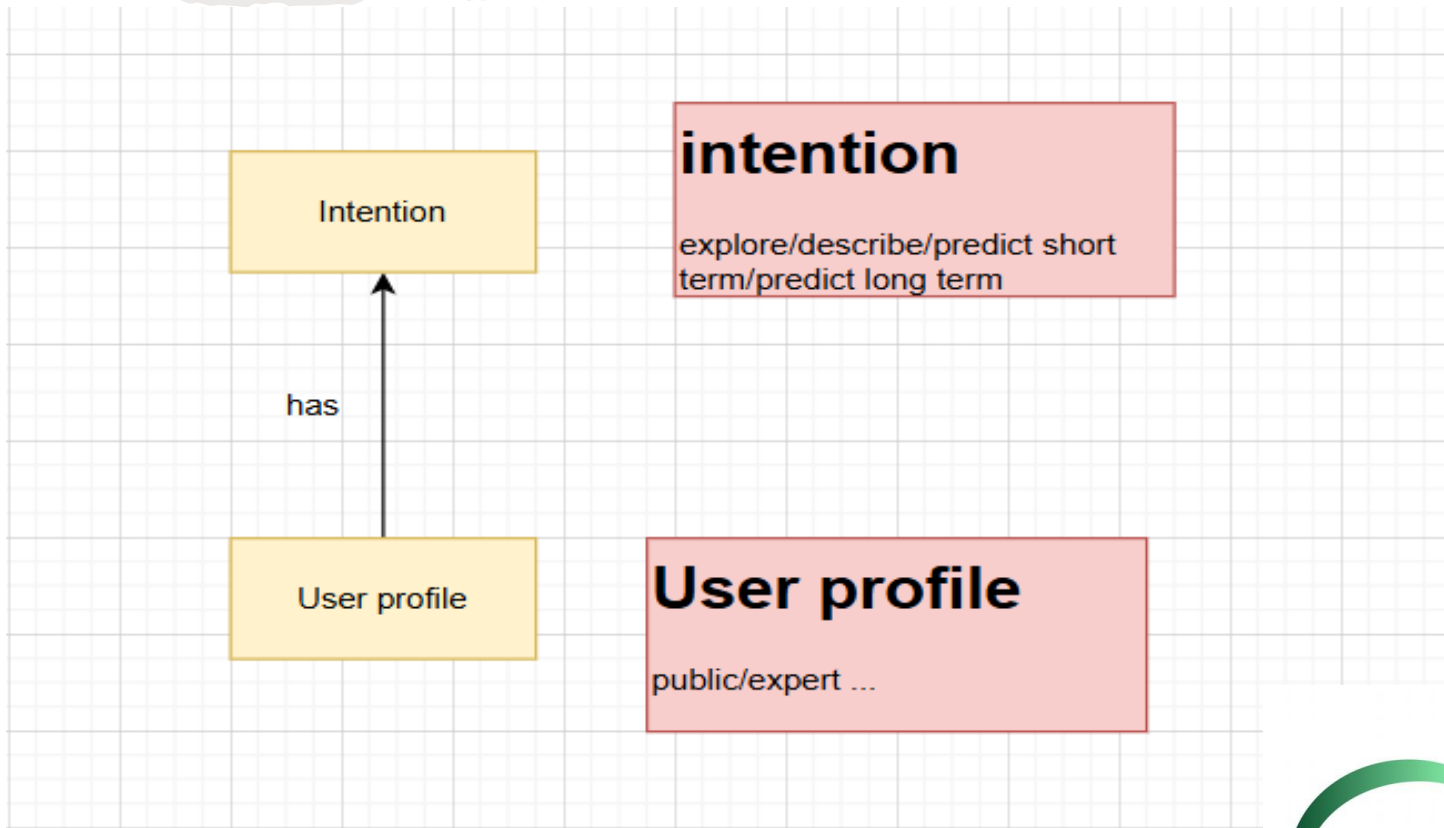
Why we need ontology?

- It acts as a semantic bridge between the user interface and the underlying Digital Twin workflow, ensuring coherent interpretation and alignment across system components.
- This ontology explicitly models the relationships between user intent, workflow activities, data, analytical methods, narrative patterns, and visualization strategies.
- We will explore the power of ontologies for mapping engine.



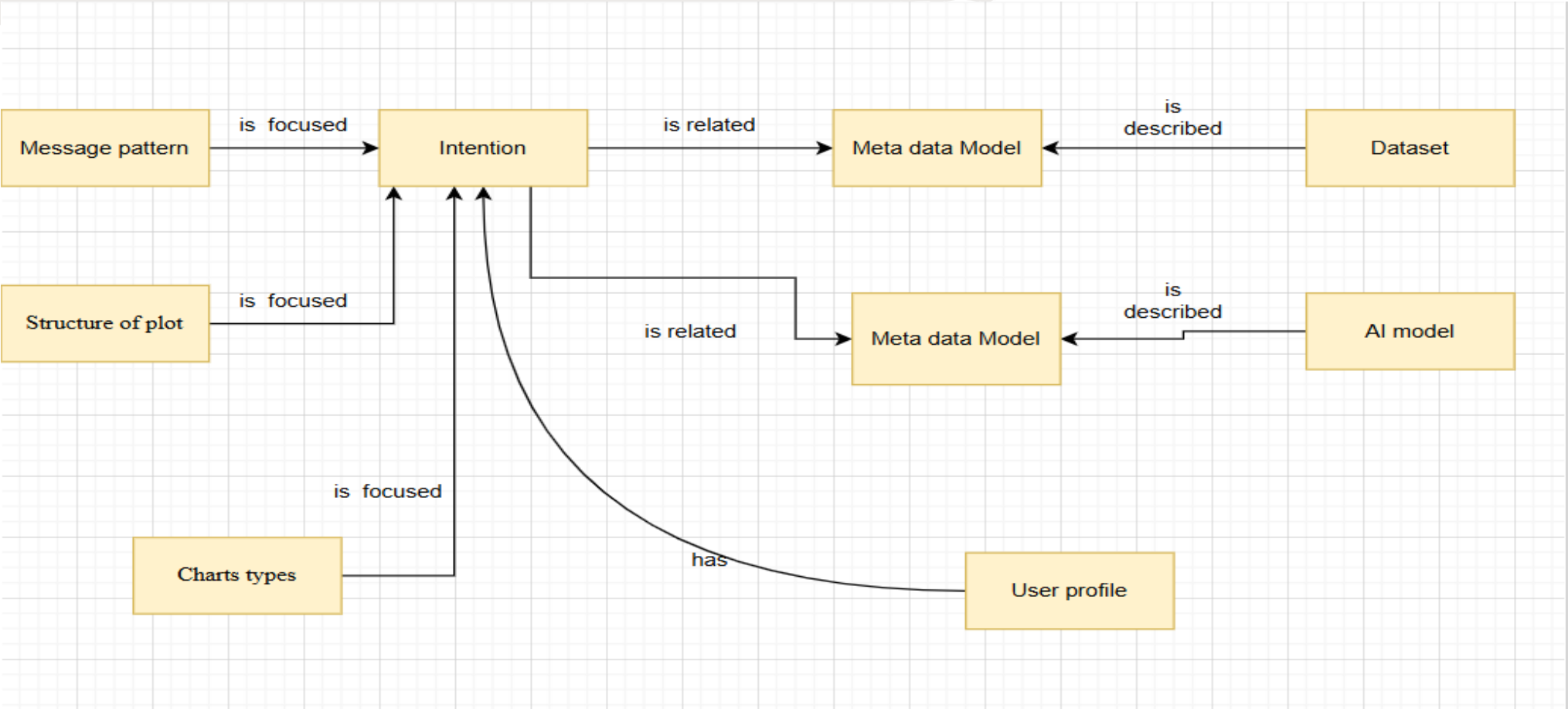
JUNON

The ontology

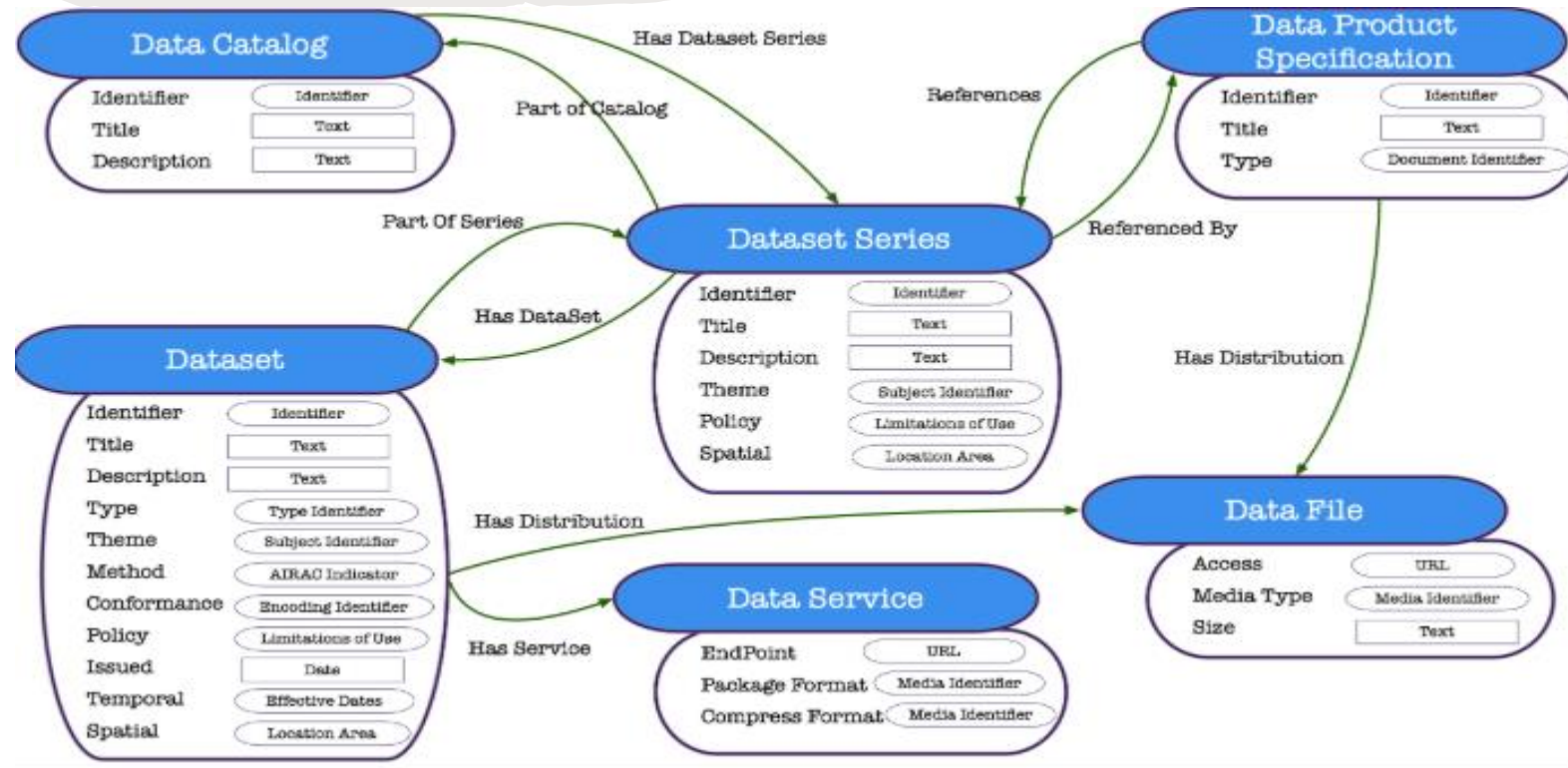


JUNON

The ontology



The ontology



The ontology

Paramètres de Requête

- **Région** : zone géographique.
- **Polluant(s) ciblé(s)** : choisissez un ou plusieurs polluants.
- **Profil** : les interprétations générées seront adaptées aux publics grand public ou aux experts du domaine.
- **Objectif** :
 - **Décrire** : aperçu des niveaux actuels.
 - **Comparer** : tendances relatives.
 - **Prévoir** : estimer l'évolution future.
 - **Recommander** : recommandations d'actions.

Région (Story)

Polluant(s) ciblé(s)

Profil

Objectif

Du Au

Prévision (si applicable)

Sources (Expert)

 Générer la Data Story

SPARQL Query

DEMO POC Qualité de l'Air Régionale



Future work

- Ongoing work: Evaluation of POC results
 1. User group for evaluate the generated stories
 2. Compare results : workflow with ontology and ordinary workflow
 3. Enhance the proposition regarding the results
- Short term future work:
 1. integration to JUNON prototype
 2. Evaluate results
 3. Enhance the proposition regarding results
- Long term future work:
 1. Try use cases with 2 Digital Twin
 2. How we can use ontology mapping

BRGM JUNON TEAM



