

Postdoctoral Position

Location: CNES Data Campus, Toulouse, France

Duration: Two years, starting September 2026

Scientific fields: Generative AI, Remote sensing, Applied mathematics

Applications: Coastal, Forest Digital Twins

Subject: Large Language Models for Earth Observation Digital Twins

Scientific context and goals

Large Language Models (LLMs) and Vision-Language Models (VLMs) are profoundly transforming the way complex data can be accessed, queried, and interpreted. In the field of Earth Observation (EO), they offer the prospect of moving beyond task-specific pipelines toward AI systems capable of reasoning across heterogeneous geospatial data and interacting naturally with users. However, most existing foundation models have been trained primarily on natural images and web-scale textual data, and remain poorly adapted to the specific characteristics of EO data.

Recent analyses have shown that models such as GPT-4V struggle with fine-grained spatial reasoning and structured geographic interpretation when applied to satellite imagery [1]. Although EO-focused multimodal models such as EarthMind [2] and GeoPixel [3] have demonstrated promising advances in multi-sensor understanding and pixel-level grounding, their capacity to perform higher-level reasoning across heterogeneous, large-scale geospatial repositories remains limited.

This postdoctoral project aims to design and evaluate novel LLM and VLM approaches specifically tailored to Earth digital twins. The research will be conducted within two major CNES initiatives: the Digital Twin Factory (DTF), an exploratory project dedicated to developing technological building blocks for digital twins of the Earth, and the national consortium “Jumeau Numérique de la Terre et des Territoires”, gathering fourteen institutional partners including IGN, INRIA and CEREMA. Earth digital twins introduce challenges that go beyond classical EO analysis. They require continuous data ingestion from heterogeneous sources, multi-scale spatial and temporal reasoning, and tight coupling between data-driven AI components and physics-based simulation models. Foundation models must therefore operate within structured, versioned, and provenance-aware environments, reason over dynamic state variables rather than static images, and support explainable interactions for scientific and operational users [4]. They must also handle large, distributed geospatial repositories while preserving spatial topology, uncertainty propagation, and semantic interoperability across domains (climate, land, infrastructure, risks). Addressing these constraints demands novel architectures, training strategies, and evaluation protocols explicitly designed for digital twin ecosystems rather than generic multimodal benchmarks.

[1] Zhang & Wang, Good at Captioning, Bad at Counting: Benchmarking GPT-4V on Earth Observation Data, 2024.

[2] Shu et al., EarthMind: Towards Multi-Granular and Multi-Sensor Earth Observation with Large Multimodal Models, 2025.

[3] Shabbir et al., GeoPixel: Pixel Grounding Large Multimodal Model in Remote Sensing, 2025.

[4] Zhang et al., More intelligent knowledge graph: A large language model-driven method for knowledge representation in geospatial digital twins, International Journal of Applied Earth Observation and Geoinformation, 2025.

Research plan

The postdoc will address four closely connected research axes.

1. Multimodal Digital Twin dataset construction.

Curating and structuring multimodal datasets derived from Earth Observation collections (VHR optical, SAR, thermal, LiDAR HD), in-situ measurements, and outputs of physical simulations from real Digital Twin use cases.

2. Multi-sensor integration.

Developing architectures and adaptation strategies enabling robust cross-modal alignment and reasoning over synchronized, metadata-enriched digital twin repositories.

3. Knowledge inference and geospatial reasoning.

Integrating the model with Knowledge Graphs (KGs, provided) that describe the Digital Twins. Enhancing MLLMs' capacity to extract and infer structured knowledge from aggregated data, including cross-referencing heterogeneous sources, interpreting complex environmental situations, and answering advanced spatial-temporal queries, potentially in interaction with knowledge representations.

4. Operative Digital Twin assistant.

Investigating how LLMs can trigger dedicated Digital Twin processing chains (e.g., simulations or indicator computations) to refine and substantiate their responses, moving toward interactive decision-support systems.

Desired profile

A Ph.D in a relevant field such as remote sensing, artificial intelligence, geospatial science, computer science, or a related discipline.

A strong background in deep learning and foundation models is required, with demonstrated experience in multimodal learning, LLMs or VLMs. Solid programming skills in Python and modern deep learning frameworks (preferably PyTorch) are expected, as well as experience with large-scale data processing. Prior exposure to Earth Observation, geospatial data, or environmental modeling will be considered a strong asset. A proven publication record in high-level venues is highly desirable. Excellent communication skills and the ability to work effectively within a multidisciplinary team.

Work environment

He/she will choose the methodological axes in consultation with the project leaders and within the framework of the scientific objectives.

The postdoctoral researcher will be in contact with the French and international space ecosystem: academic laboratories in several scientific fields, industrial and institutional R&D, space agencies. Funding is available for visits in other laboratories and participation in conferences. He/she will be able to supervise internships and benefit from technical support from computer engineers.

The post-doctoral researcher will be employed by CNES, CNES is the French space agency. It proposes and implements French space policy. The Data Campus brings together more than 110 engineers and researchers and is dedicated to the valorization of space data. The postdoctoral researcher will benefit from a gross salary of around €2900 over 13 months, and CNES's employee benefits (sport and cultural activities; renowned corporate restaurant...)

Application process

Applications can be submitted until March 23 on the CNES recruitment platform:

<https://recrutement.cnes.fr/fr/annonce/2698873-24-302pd-surrogate-model-devpt-for-thematic-earth-observation-digital-twins-31400-toulouse>

The application should include :

- Updated academic CV
- A two-page description of the work undertaken during your Ph.D.
- A covering letter
- A research project (maximum two pages, including references).
- A letter of recommendation from your Ph.D. supervisor
- If deemed appropriate, one or two other letters of recommendation

Applicants are invited to contact the CNES project coordinators before submission:

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