**Research Experience Placement (REP) Scheme 2024**

**Supervisor Project Proforma**

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| **Project title:** | Developing an environmental Digital Twin demonstrator for outreach applications |
| **Host Institution:** | National Centre for Earth Observation, University of Leicester |
| **Project supervisor (name, department):** | Dr Cristina Ruiz Villena, National Centre for Earth Observation |
| **Project enquiries (supervisor email):** | crv2@le.ac.uk |
| **Co-Supervisor, if any (name, department):** | Dr Robert Parker, Dr Josh Vande Hey, and Rose Meadows (NCEO Outreach Officer) |
| **Proposed start date:** | From end of June 2024 onwards (flexible) |
| **Project description**: |
| Digital Twins (DTs) of the environment are an emerging field of research that aims to provide a new way to turn data into actionable information. A Digital Twin is a digital replica of a physical system that has some predictive capability (a model), can integrate observations from multiple data streams, typically involves machine learning, and can help us plan and implement interventions by allowing us to explore ‘what-if’ scenarios. DTs of the Earth are becoming very relevant in the context of climate change as powerful tools to support decision making in mitigation and adaptation efforts. As an emerging technology, the concept of environmental DTs is still unclear to many scientists, and particularly lacking in public awareness. Outreach materials can be very effective in communicating complex scientific concepts to a wide audience of non-experts, as demonstrated by the myriad of successful activities that exist for other topics. For example, at NCEO and the University of Leicester Earth Observation Science group we have been able to explain how remote sensing works to children and adults countless times using a thermal camera, which has always been educational and fun. Therefore, an interactive outreach activity could be a great way to convey the complex concept of environmental DTs not only to the wider public, but to other researchers and scientists. In this project, the candidate will aim to develop an environmental Digital Twin demonstrator that can help us communicate how DTs work, as well as their purpose and wider societal impact. The demonstrator will consist of:* **A physical component (the ‘Physical Twin’)**, which will involve small sensors. For example, it could be a small enclosure with sensors monitoring variables such as CO2, temperature, humidity, etc. There might be an opportunity to include 3D-printed elements in the prototype.
* **A digital component (the ‘Digital Twin’)**, which would involve creating a simple model, potentially using machine learning, that takes in the observations and allows the user to make changes and explore the outcomes through an interactive dashboard. The DT would serve two purposes: provide predictions to help make decisions; and the ability to effect changes in the physical component and explore the result.

The specific details of the application can be tailored to the candidate’s interests, giving them the opportunity to be creative and propose their own solution. The resulting demonstrator will be used in science communication and outreach activities in years to come to showcase the concept of Digital Twins.The project offers the candidate an opportunity to develop skills and knowledge related to:* The relevance of Digital Twins as environmental decision support tools.
* The importance of effective science communication and outreach materials.
* Model development in Python.
* Creative system design and independent thinking.
* Implementation of an end-to-end prototype with physical sensors.
* The use of High-Performance Computing for environmental science.
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| **Project timeline:** |
| **Project Duration**: 6+ weeksThe project will be at least 6 weeks, with the possibility for a longer placement if funds allow.**Weeks 1-2**: Initial research and demonstrator design. The candidate will conduct the necessary reading, as well as brainstorming sessions with the supervisory team, to decide the details of the Digital Twin application to be developed according to their interests. Aspects of the design to be decided include: overall objective of the system (e.g. a miniature Digital Twin of a thermally controlled room), physical variables to be measured (e.g. temperature, relative humidity, etc.), sensors needed, type of platform (e.g. clear Perspex box, 3D-printed enclosure, etc.), and model to use in the digital part of the system.**Weeks 3-4**: Implement and test model using Python. The particular model used will depend on the specific application selected in the design phase, but it will be a simple model involving a number of inputs and outputs that connect the Digital to the Physical Twin, and it could include some machine-learning algorithms. This phase will involve developing a simple interface for data visualisation and user interaction with the Digital Twin.**Weeks 5-6**: Build Physical Twin and integrate measurements from sensors into the Digital Twin. This phase will involve building the physical system, implementing code to read the sensors’ outputs, most likely on a microcontroller such as Arduino, and input the data into the model. **Weeks 7+:** Potential extensions to the project include further refining the prototype or user interface, adding more sensors, and taking the demonstrator to a science outreach event to test it with an audience. |
| **Candidate requirements:** |
| This project would suit a candidate with prior knowledge of the Python programming language. Experience with sensors and microcontrollers is desirable. Part of the project is expected to be lab-based and part is expected to be computational.The candidate would ideally be located at Space Park Leicester for some of the project duration (particularly the Physical Twin aspects) but we are flexible in relation to remote working should that be necessary. |
| **Background reading and references:** |
| Bauer, P., Stevens, B. & Hazeleger, W. **A digital twin of Earth for the green transition**. Nat. Clim. Chang. 11, 80–83 (2021). <https://doi.org/10.1038/s41558-021-00986-y>. Komninos, A. & Tsigkas, G. 2022. **Prototyping a Digital Twin System for Environmental Education**. In 26th Pan-Hellenic Conference on Informatics (PCI 2022), November 25–27, 2022, Athens, Greece. ACM, New York, NY, USA, 6 pages. <https://doi.org/10.1145/3575879.3576018>. ‌ |

**To be completed by institutional CENTA PoC**

I confirm that:

* The host institution takes responsibility for selecting a suitable undergraduate student and ensuring eligibility (see NERC REP student eligibility requirements above) and confirming their eligibility using the UKRI criteria listed under the NERC REP student eligibility criteria
* This REP project falls within the NERC remit and is of suitable quality
* Appropriate supervisory arrangements are in place
* The student recruited to undertake this placement will have a PhD student mentor from the DTP/CDT
* The application processes used will be inclusive and accessible
* Reasonable adjustments will be made for students that need them whilst undertaking placements
* The placement will be carried out in accordance with all applicable ethical, legal and regulatory requirements including but not limited to relevant provisions of the General Data Protection Regulation, the Data Protection Act 2018, the Bribery Act 2010, the Fraud Act 2006, the Equality Act 2010 and the Modern Slavery Act 2015
* The host organisation takes responsibility for identification, protection and exploitation of any intellectual property rights arising from the work
* All facilities, agreements about access and collaborations necessary for the work will be obtained before the work commences and can be ensured through the period of the work
* All costs awarded by NERC for the REPs will be used and accounted for appropriately
* A report of the project by the student will be submitted no later than one week after the end date of the placement or Friday 27th September 2024, whichever falls first.

Signed: 

Date: 25/4/2024

Position: NCEO CENTA POC