UNIVERSITY OF LEICESTER

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Using Machine Learning to Evaluate and Understand our Capability to Model Tropical Wetland Methane Emissions

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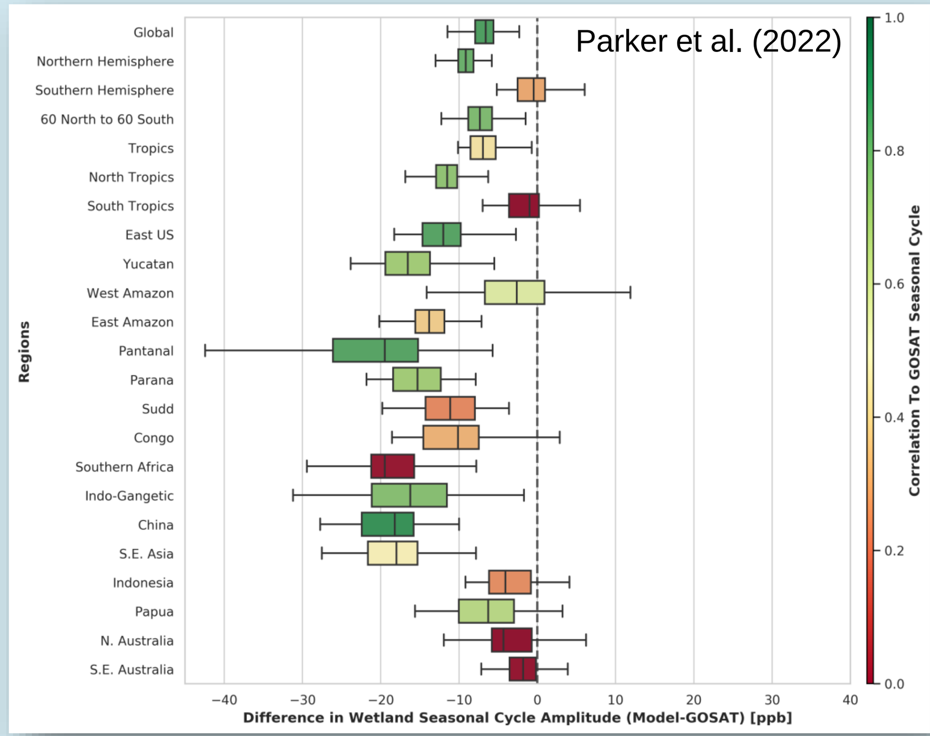
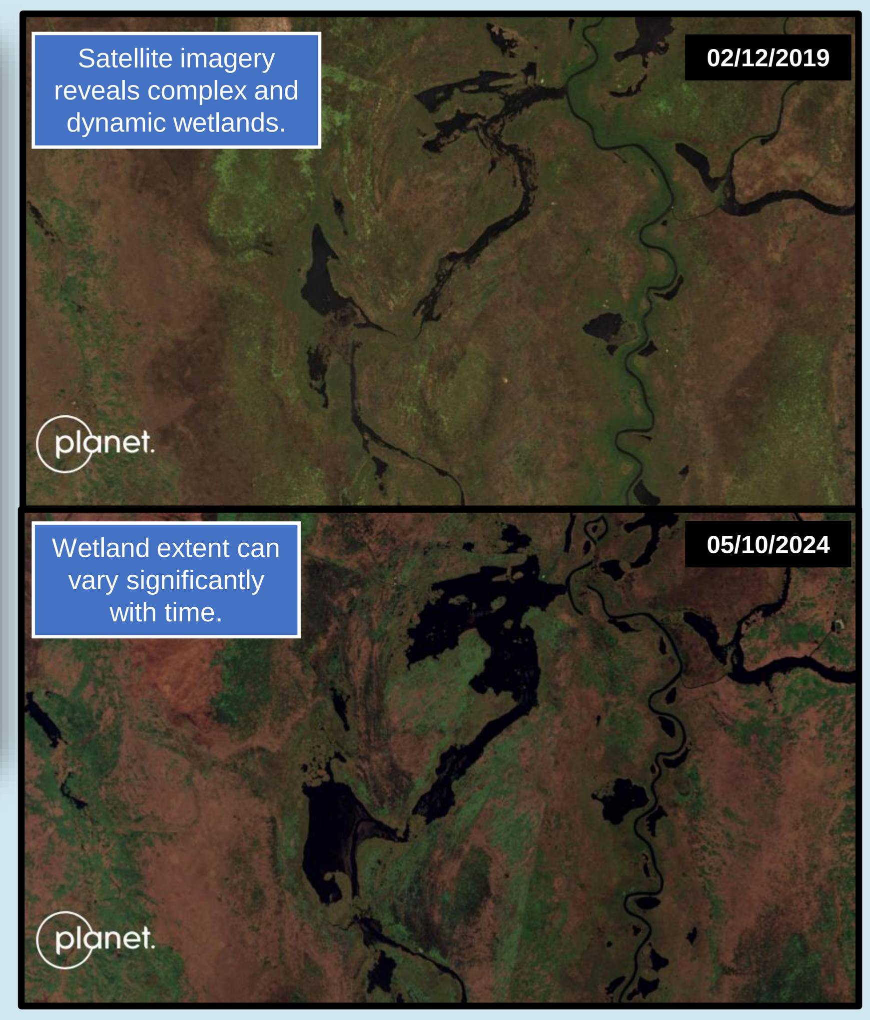
1 Motivation | Wetlands

- **Wetlands** – the largest natural source of methane – are complex ecosystems, challenging to model and measure.
- There are large **uncertainties** associated to wetland methane emissions, particularly in tropical Africa.
- These uncertainties **reduce our ability to model** wetland methane, with many models disagreeing.
- **Wetland extent** is complex and highly variable.

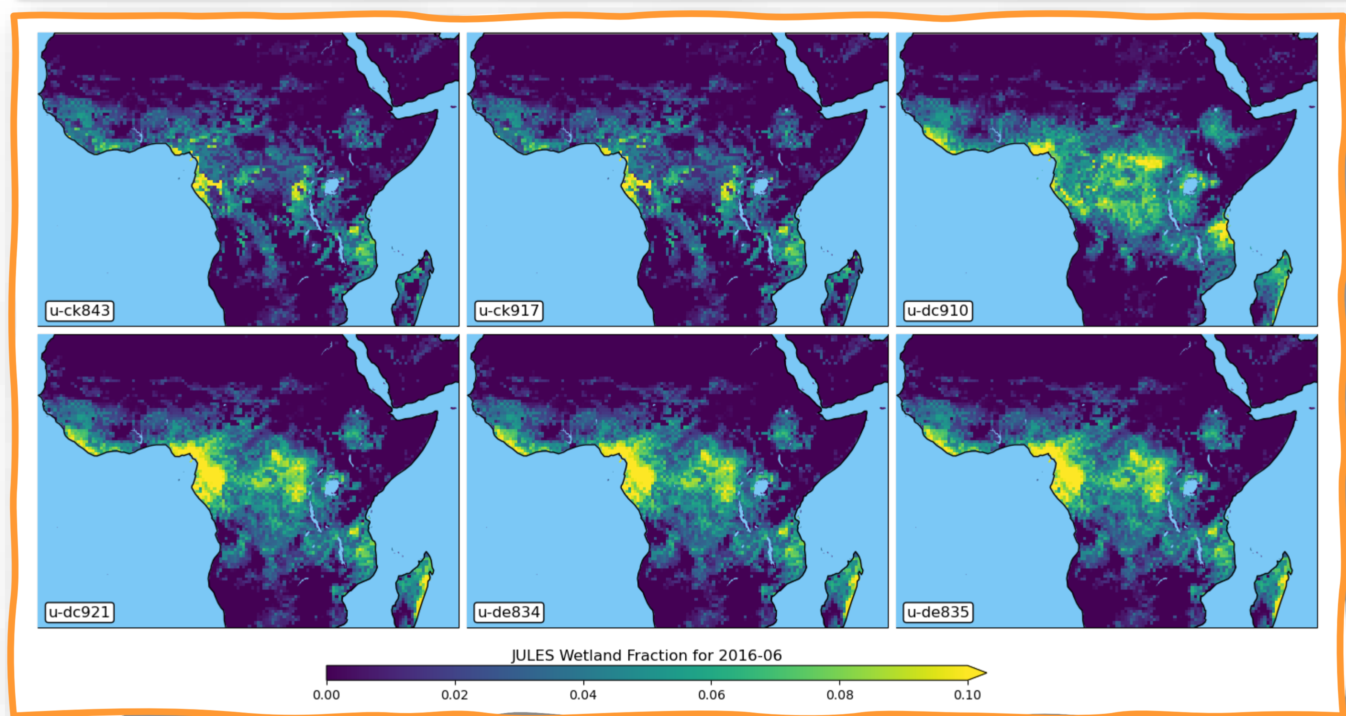




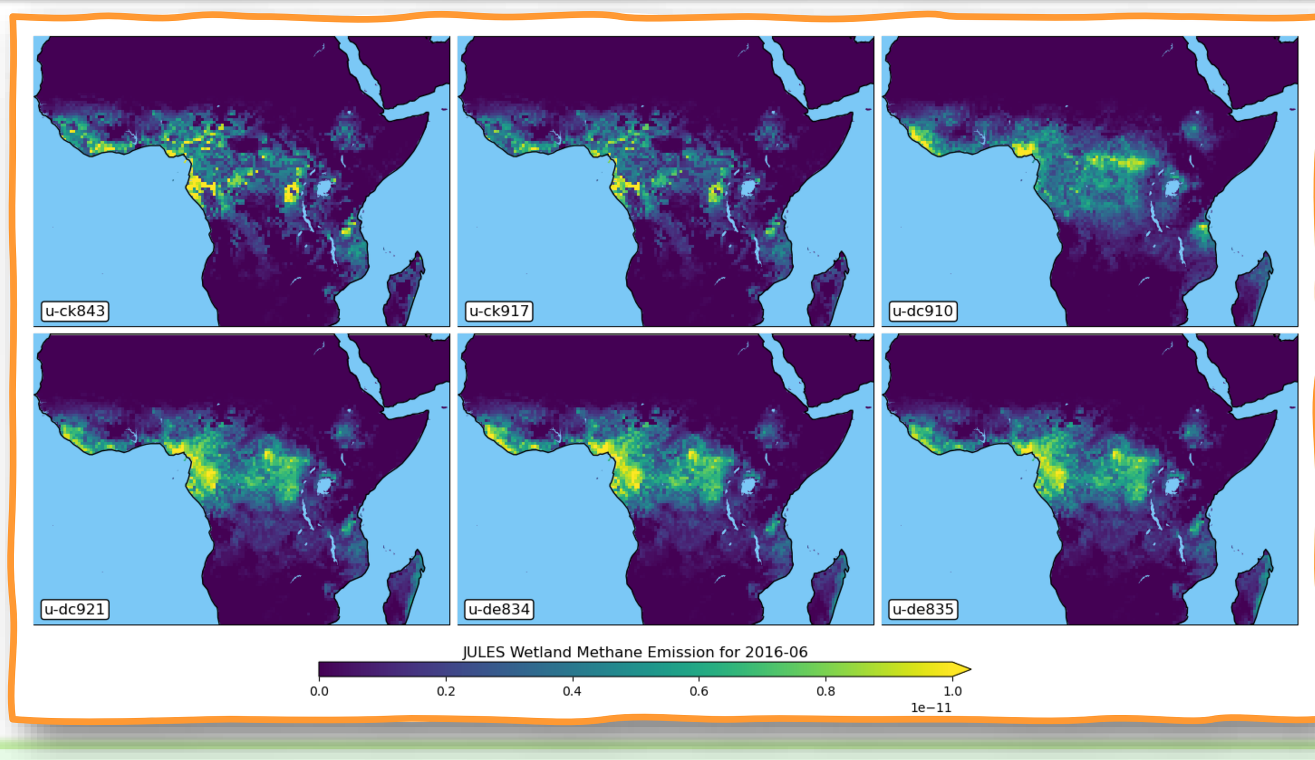
Key Questions

1) How are **tropical wetland methane emissions** responding to **climate change**?
2) How will they continue to do so under **future climate scenarios**?

2 Methodology



Wetland Extent ← **JULES** Joint UK Land Environment Simulator — Ensemble of simulations → Wetland CH_4



Emulator Methodology

1. We train a **machine-learning** decision-tree model (*emulator*) using JULES data to reproduce wetland extent and methane emissions.
2. We **drive the emulator using EO data** to generate new datasets.

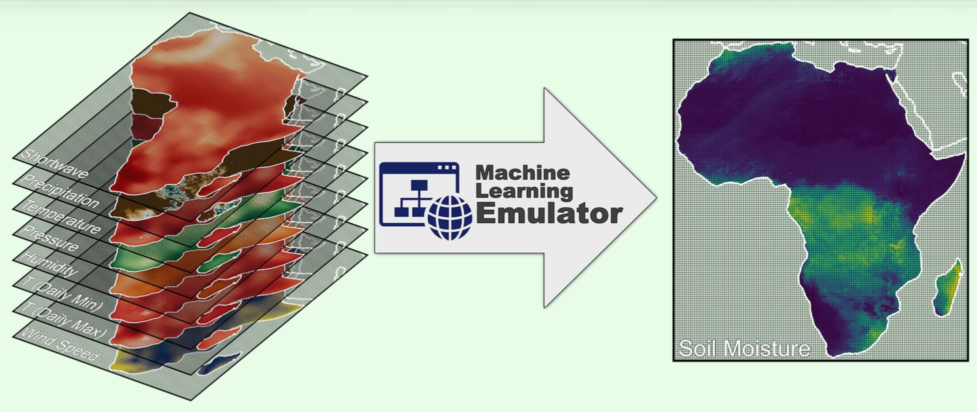
Advantages

- ✓ We can run many simulations **very fast**
- ✓ **No** need for **expert** knowledge
- ✓ **No** need for expensive **supercomputers**
- ✓ We can derive **useful metrics** for users
- ✓ They can be deployed on **web platforms**
- ✓ They can integrate **many types of data**
- ✓ **Explainable AI.**

Emulator ↓ **EO Driven**

Model-data fusion

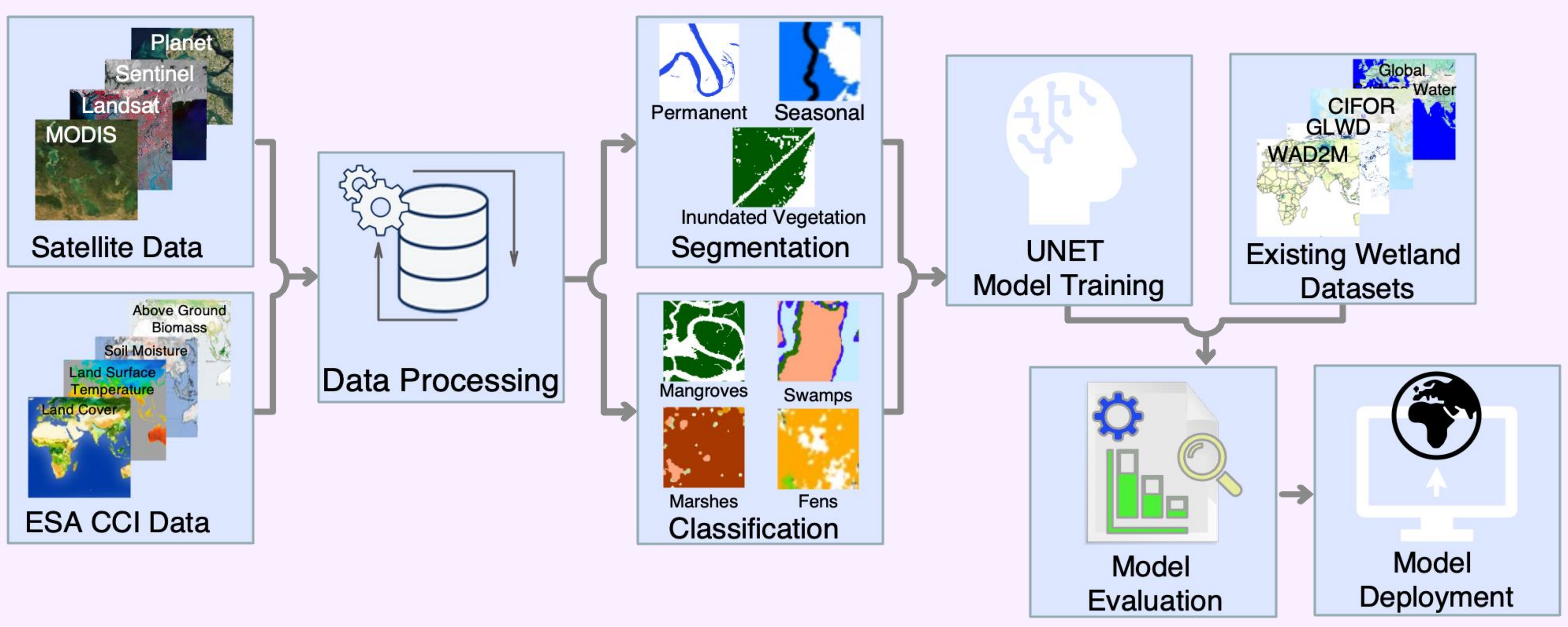
We will **drive the emulator** with input based on **ESA-CCI data** to produce new wetland CH_4 emissions, consistent with observed LST and soil moisture.



From emulators to Digital Twins

Emulators are building blocks for Digital Twin applications. They provide **decision support** by allowing the user to test '**what-if' scenarios**.

EO-based Extent vs **Wetland Extent** | **Methane (CH_4)** vs **EO Methane Obs.**

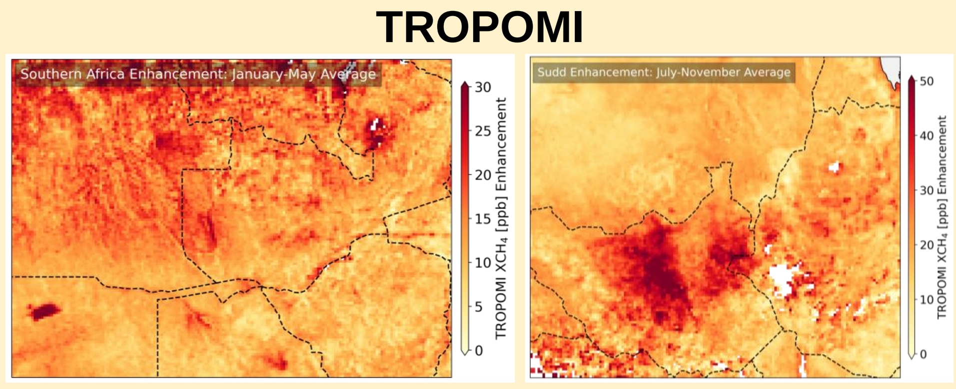


AI-driven Wetland Mapping: Precision Classification and Extent Estimation using Earth Observation Data

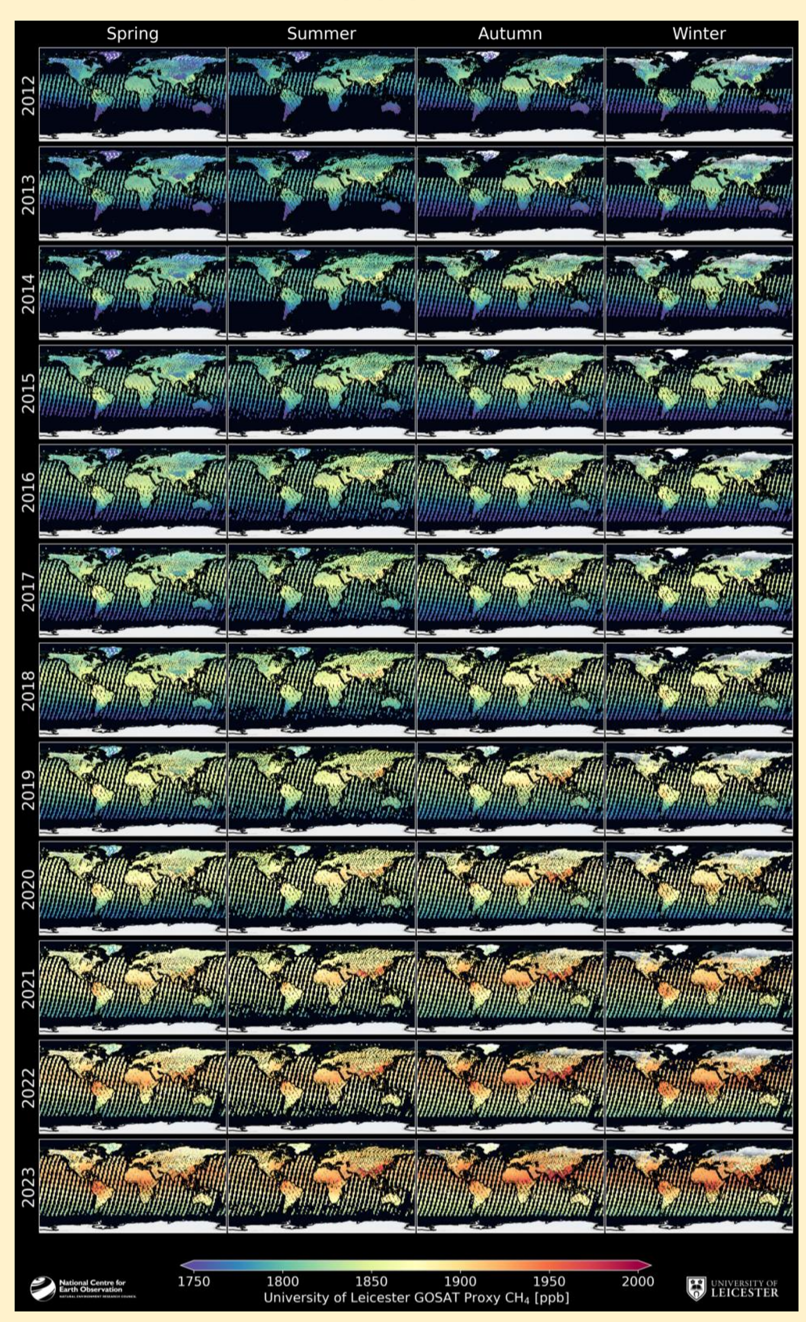
ESA CCI Methane Datasets

Emulator emissions will be evaluated against **atmospheric inversions** of ESA CCI CH_4 data, including uncertainties.

TROPOMI



GOSAT



3 Next Steps | Towards a Digital Twin

- **Develop** and **optimise** wetland extent and methane **emulators**.
- Use **explainable AI** for better **process understanding**.
- Improve mapping of **wetland extent** using AI and EO data.
- Generate new **JULES** runs with **improved hydrology**.
- Build **wetland Digital Twin** applications based on the emulators.

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EOCIS Earth Observation Climate Information Service

UK Research and Innovation