UNDERSTANDING CHANGES IN TROPICAL WETLANDS WITH REMOTE SENSING, MACHINE LEARNING AND LAND SURFACE MODELLING

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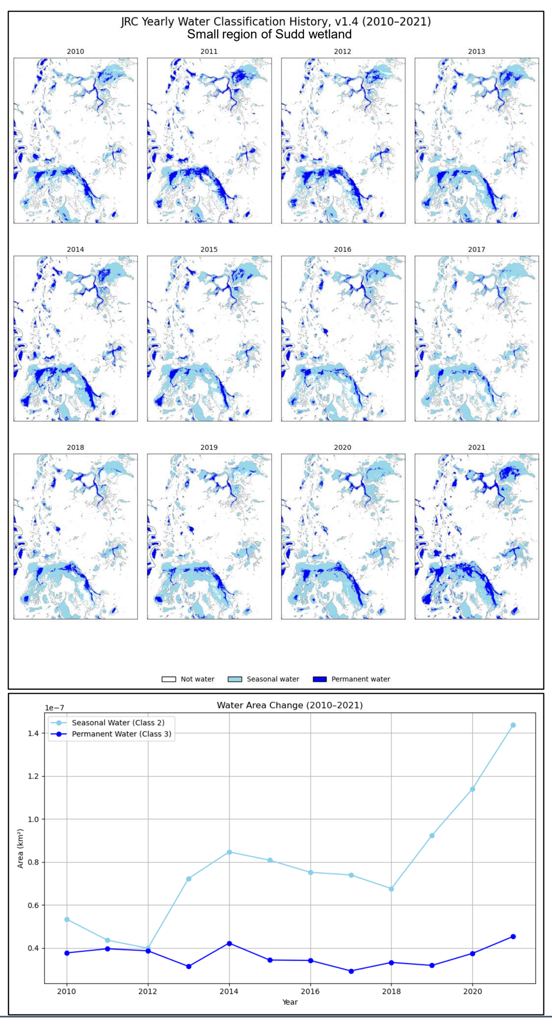
1. Introduction

- Wetlands occupy just ~ 6% of Earth's surface but store 20-30% of global organic carbon. They are both the largest natural methane source and the most effective ecosystems for long-term carbon storage [1].
- Tropical wetlands alone release 90 Tg CH_4 year^{-1} and 3860 Tg CO_2 year^{-1} underscoring their critical role in the global carbon cycle [2].
- Within tropical regions, up to 80% of the uncertainty in wetland emissions of CH4 can be associated with the uncertainties in wetland extent [3].
- This study aims to address the poorly quantified tropical wetland extent and seasonal dynamics through Earth Observation and Land Surface Modelling approaches.

2. Importance

JRC Global Surface Water- yearly water classification: Seasonal water shows a significant increase after 2018 with peak values in 2020, 2021; permanent water remains relatively stable; a small increase after 2021.

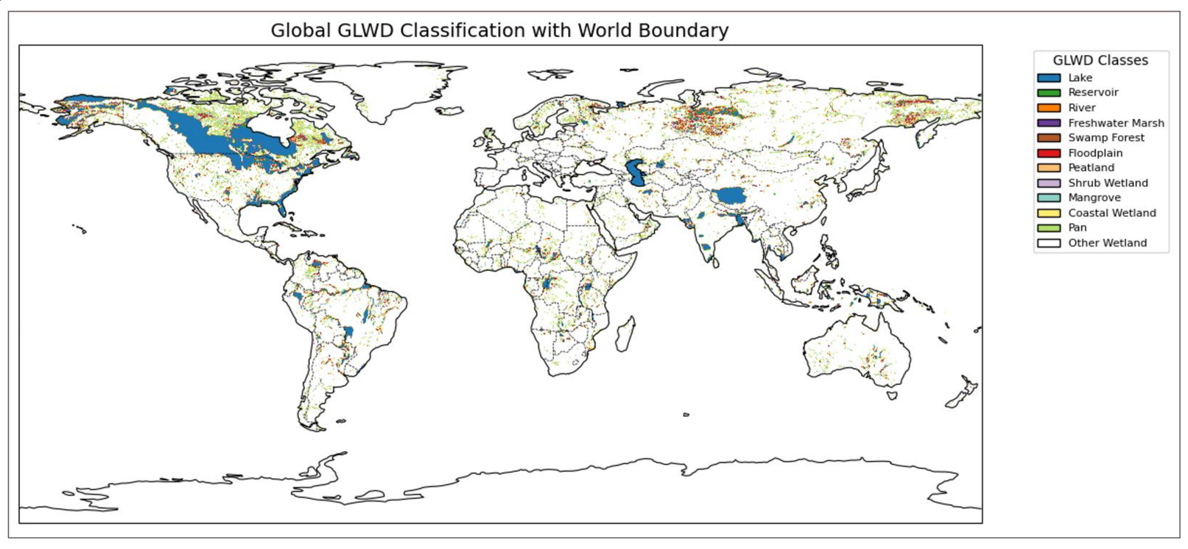


Large uncertainties remain in mapping the spatial extent and classification of tropical wetlands which further complicate accurate carbon modelling and upscaled estimates.

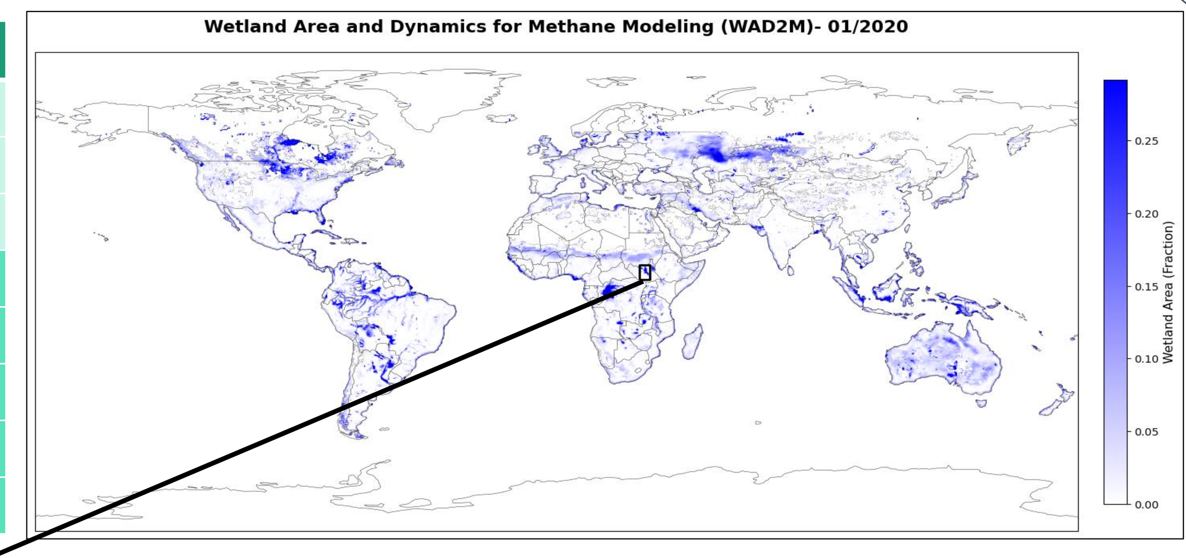
Research Aims:

- Quantify recent changes in tropical wetland extent and identify key environmental drivers.
- Assess the ability of remote sensing datasets (e.g., WAD2M, GLWD, CYGNSS) to capture seasonal and inter-annual wetland dynamics and evaluate associated uncertainties in methane emission estimates.
- Evaluate how well Land Surface Models represent wetland dynamics, and explore integration of Earth Observation data, machine learning, and modelling to improve predictions under future climate scenarios.

3. Earth Observation data



Dataset	Type	Resolution
GlobCover	Static	30 m
SWAMP	Static	231 m
GLWD	Static	1 Km
JRC GSW	Dynamic	30 m
CYGNSS	Dynamic	1 Km
WAD2M	Dynamic	25 Km
WetCHARTs	Dynamic	50 Km
GRACE	Dynamic	100 Km



SPATIAL CHARACTERISATION OF TROPICAL WETLANDS:

- Provides key differences in spatial representation and classification detail across various static datasets.
- Spatial analysis will help in comparison of wetland coverage highlighting discrepancies in extent and thematic classification between products.

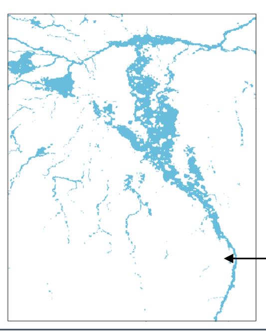
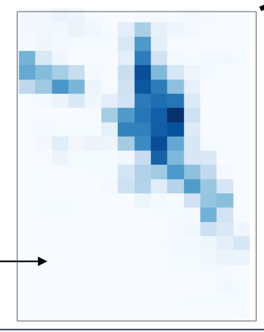


Table: Region focussing over Sudd wetlands comparing CYGNSS Watermask and WAD2M data.

CYGNSS Watermask (1km)

WAD2M (25km)



TEMPORAL ANALYSIS OF WETLAND INUNDATION DYNAMICS:

- Dynamic products allow detailed monitoring of intra & inter-annual fluctuations.
- Time-series plots will help to assess temporal patterns, while moving averages and anomalies will smooth the trends and identify deviations from overall average.

4. Model Simulation

Ancillary Data

- Soil
- Hydrology & Topography
- land cover cci
- HydroSHEDS — TWI: Topographic Wetness Index + DRT: Direction of River Trajectory

PREPROCESSING

- Subset Sudd Wetland Region
- 10 km Grid
- NetCDF

Driving Data

- CMIP6 — Global Climate Models
- UKESM1-0-LL — Selected Climate Model
- ISIMIP
- 2015 - 2024
- Daily NetCDF

JULES Model

JULES Joint UK Land Environment Simulator

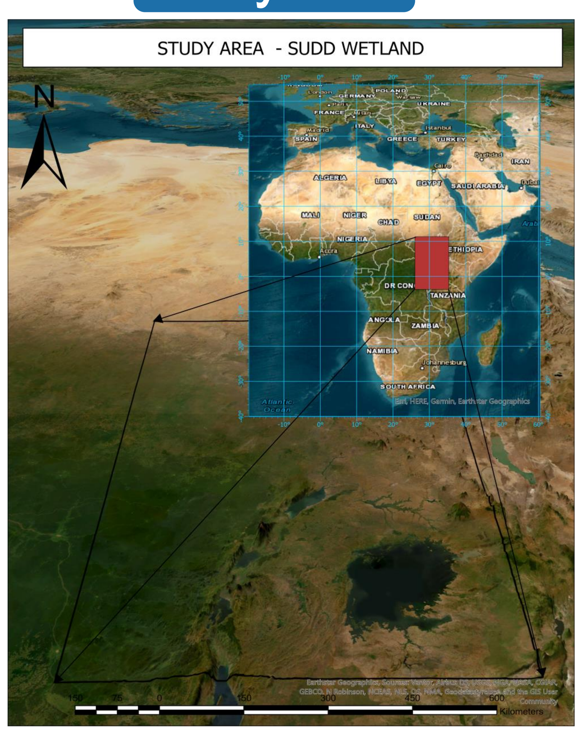
- Rose configuration
- Generate name-lists
- Run JULES

JULES Model Output State Variables

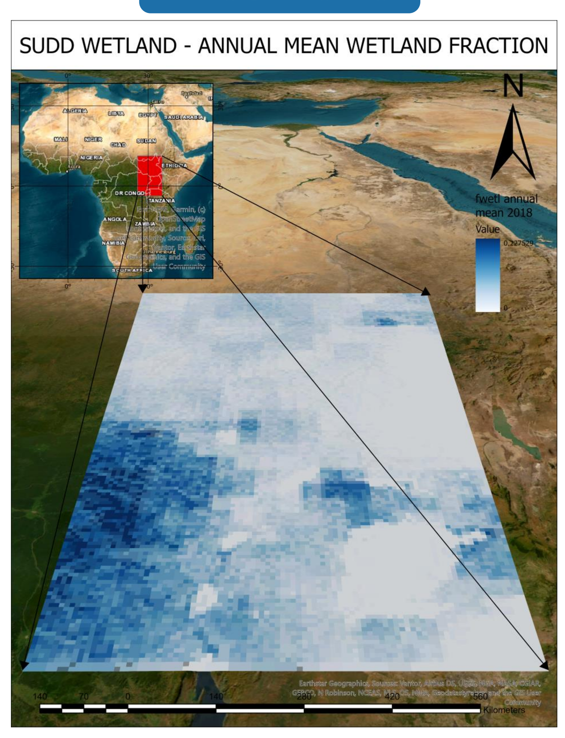
- **fwetl** Wetland fraction
- **fsmc** Soil moisture
- **precip** Gridbox precipitation rate
- **runoff** Total runoff
- **gpp/npp** Gross/Net primary productivity
- \+ other variables

5. JULES initial results

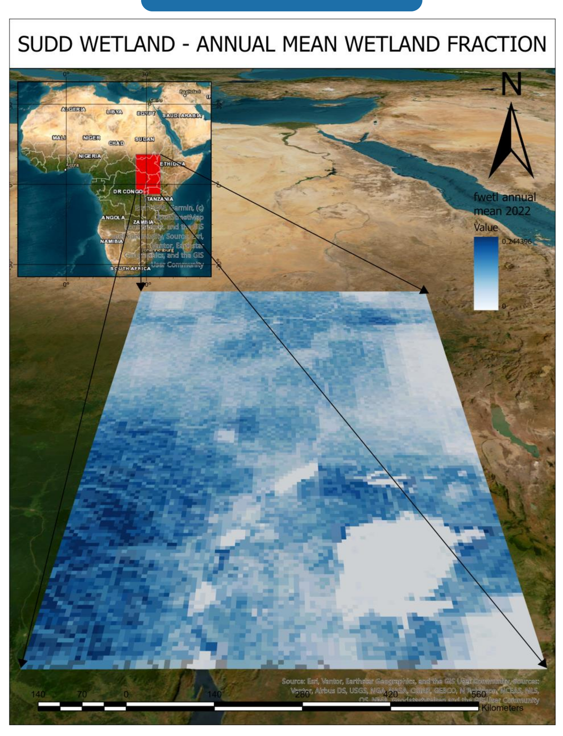
Study Area



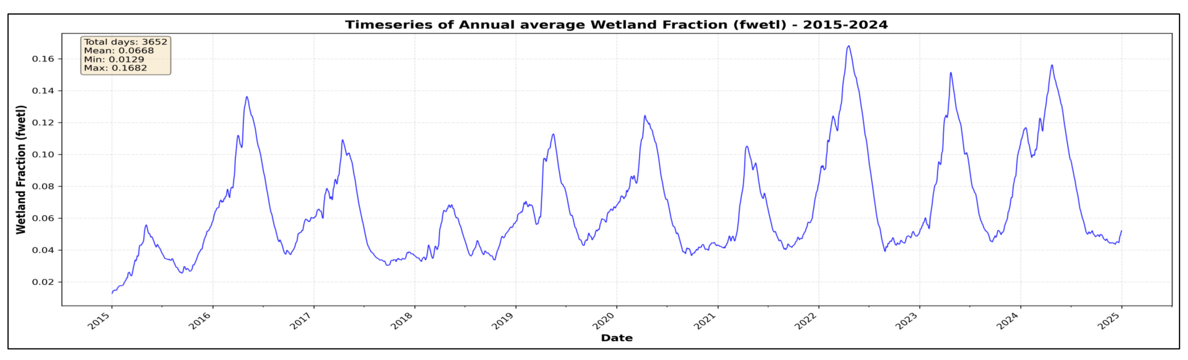
fwetl 2018

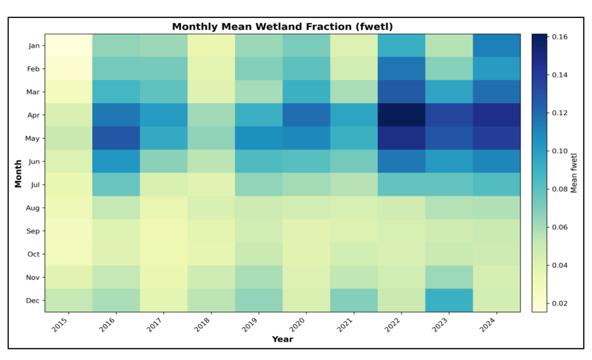


fwetl 2022



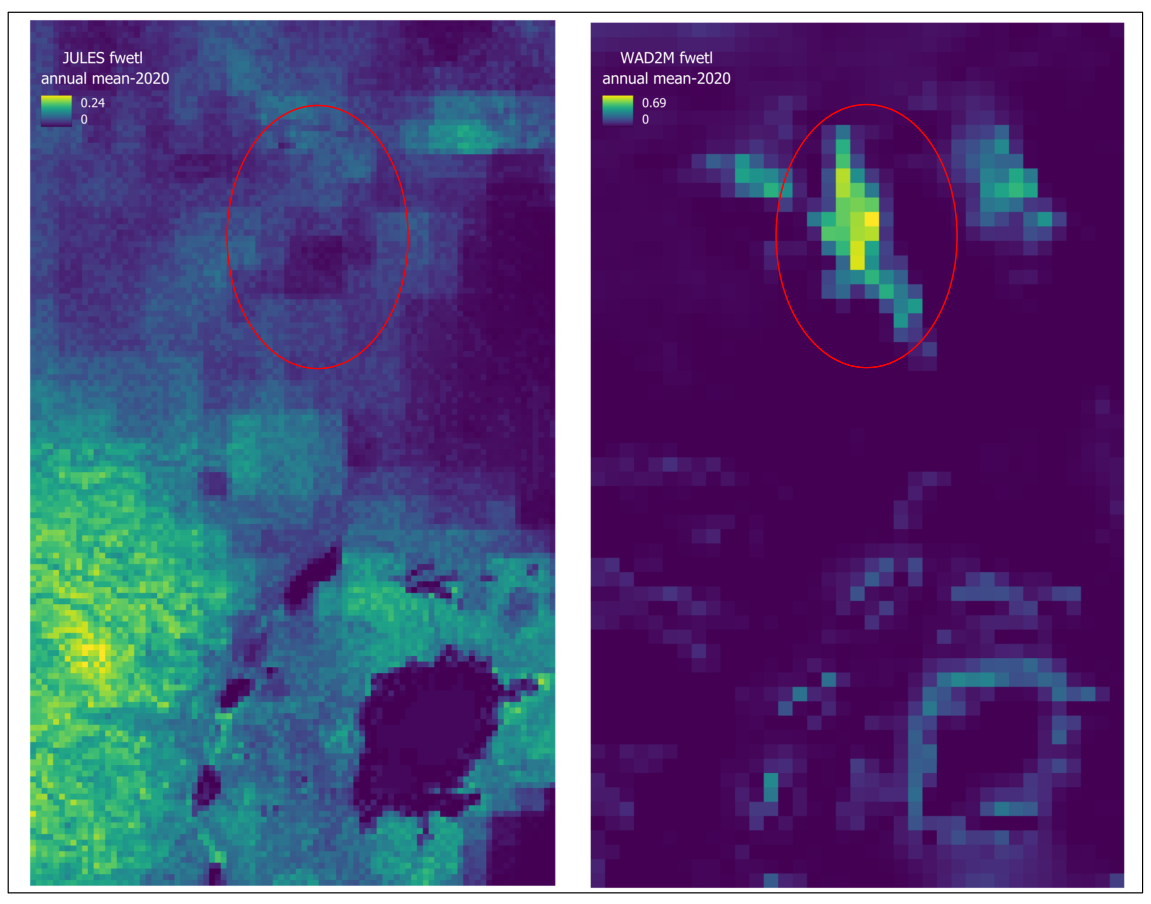
Temporal and Spatial Wetland Variability





Key Findings

- **Strong seasonal wetland dynamics** Peak inundation March-May; least fwetl Aug-Oct
- **Clear interannual variability** 2015 least inundates vs 2022 highest inundated
- **Model - data discrepancy** Differences observed between JULES-simulated wetland extent and WAD2M dataset



Model vs EO: wetland fraction comparison

6. Conclusion & Future work

- JULES Land Surface Model successfully captures wetland extent dynamics in the Sudd wetland region of South Sudan, showing clear seasonal and interannual variability.
- Distinct wet (2022) and dry (2015) years highlight the sensitivity of wetlands to climate variability.
- There is a visible discrepancy between wetland fraction region shown in JULES model output compared to WAD2M data.
- Further analysis includes:
  - Comparison of different JULES configuration (RFM vs CaMa Flood)
  - Higher spatial resolution simulations
  - ML approach such as XGBoost to be applied to JULES derived variables to improve the representation and prediction of wetland extent.

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References: [1] Mitsch et al., 2010; [2] Sjögersten et al., 2014; [3] Bloom et al., 2017;

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