

# The use of artificial intelligence to monitor the Living Fuel Moisture Content from LDAS-AROME outputs

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## What are we aiming at?

- ▶ In order to prevent wildfire spread, the sparse and irregular distribution of in-situ LFMF measurements poses a significant challenge. Considering LFMF as a key variable, we rely on a neural network to model it using model-based inputs.
- ▶ Our goal is to develop a neural network that can be used operationally by fire management services, leveraging LDAS outputs to support ignition risk assessment.

## What is the LFMF?

- ▶ LFMF [1] ~ it is an in-situ data evaluated by measuring the difference between the fresh mass and the dry mass of vegetations exprimed as :

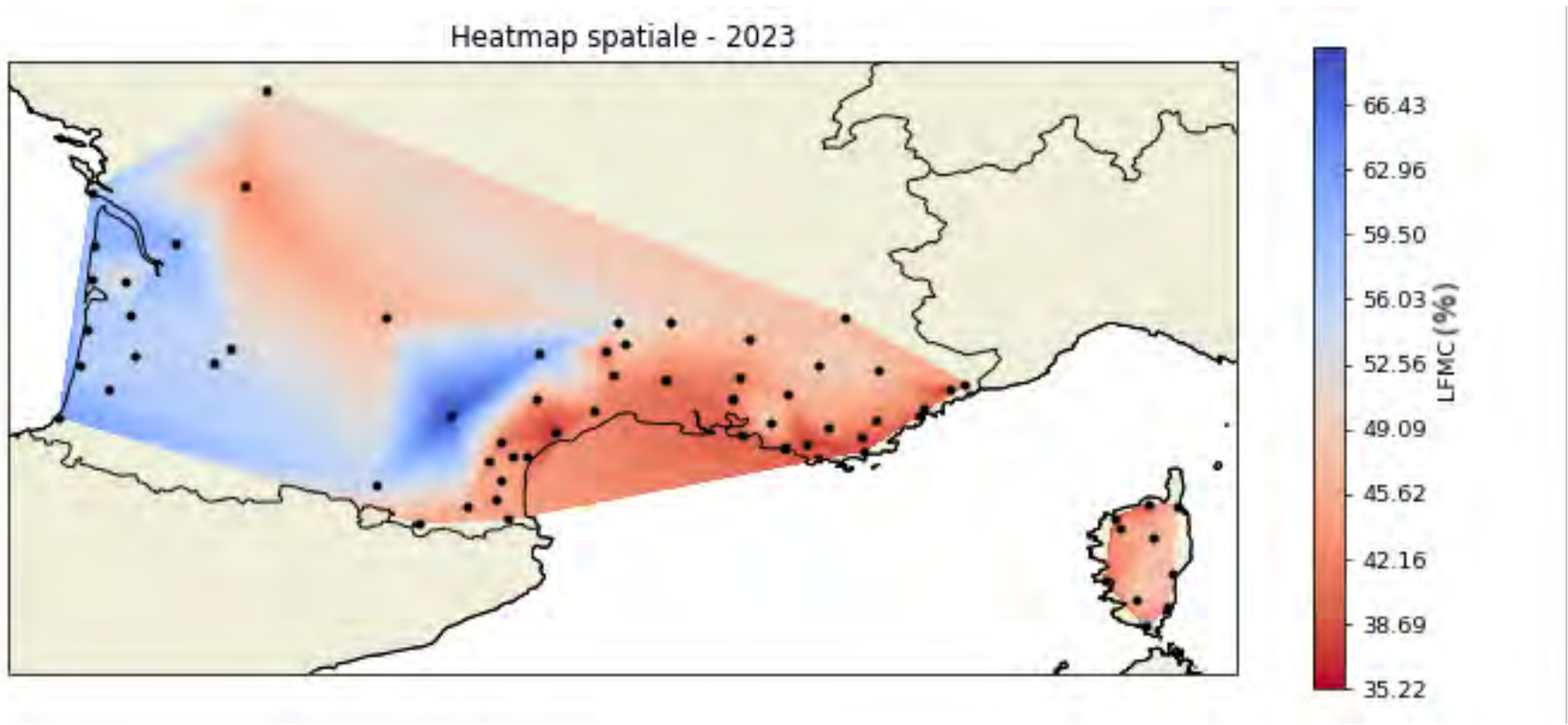
$$LFMF = \frac{MassFresh - MassDry}{MassDry}$$

## Which inputs use for the learning process?

- ▶ ISBA Model :
  - Inputs are extracted from the ISBA land surface model after the assimilation of observed Leaf Area Index (LDAS, Land Data Assimilation System).
- ▶ Different categories :
  - Geographical parameters: Day of Year, Orography, Slope, ....
  - LDAS outputs: Leaf Area Index (LAI), Soil Water Index (SWI), Biomass, ....
- ▶ Mixed inputs :
  - LAI/WWILT, LAI/WFC,  $\sum$ Biomass.

## What database are we considering?

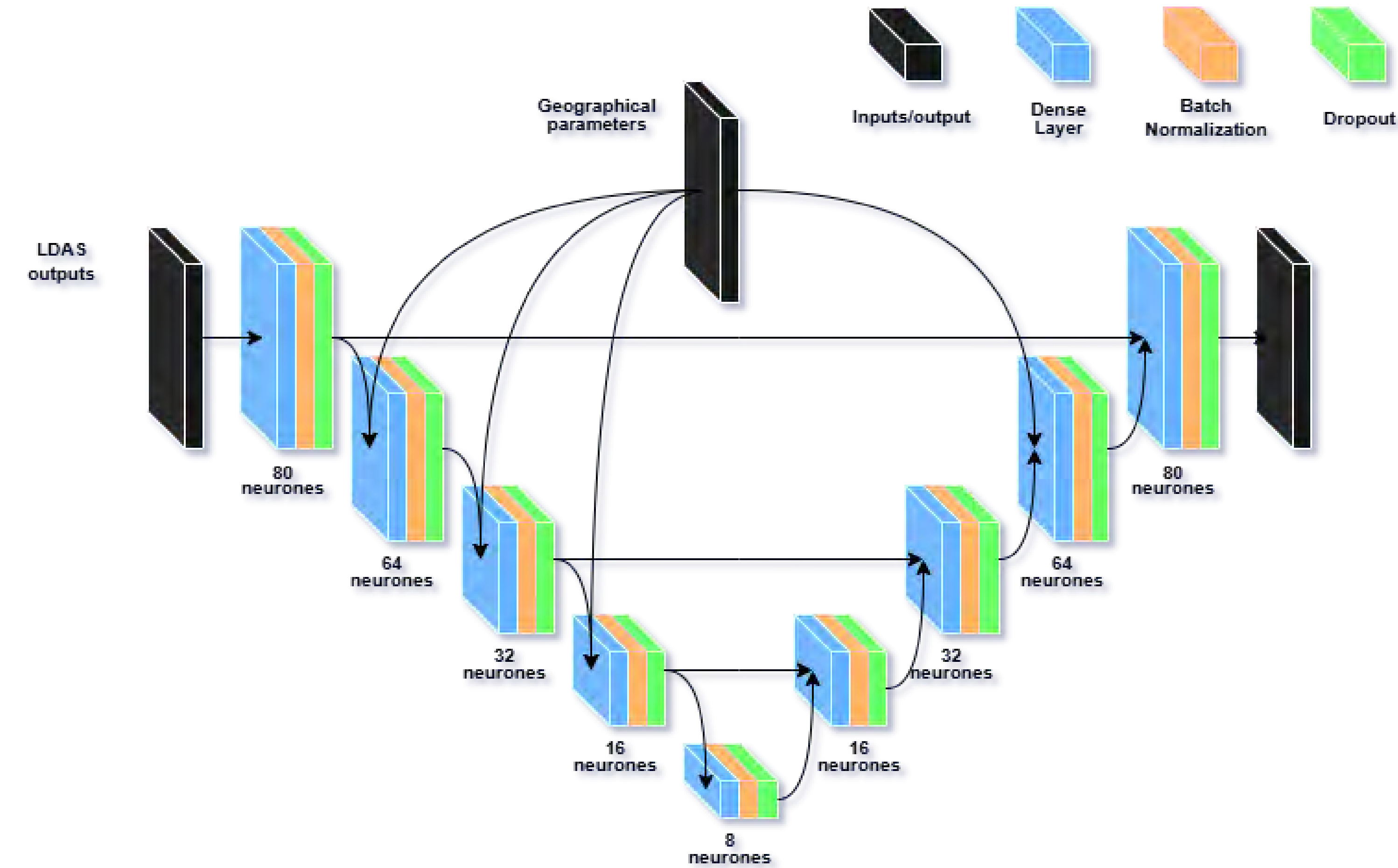
- ▶ Our study relies on the ONF 'réseau hydrique' database. For each LFMF site, we extract a pixel at 0.25° resolution centered on its location [2].
- ▶ LFMF's values are averaged by site and date to have a representative value per sites to avoiding species complexity and better operational interpretations.
- ▶ Train Dataset covers from 2017 to 2022, Validation Dataset covers the year 2023, Test Dataset the year 2024.



Example of the sites of the year 2023 and the interpolated values of LFMF in %

## What kind of neural network are we using?

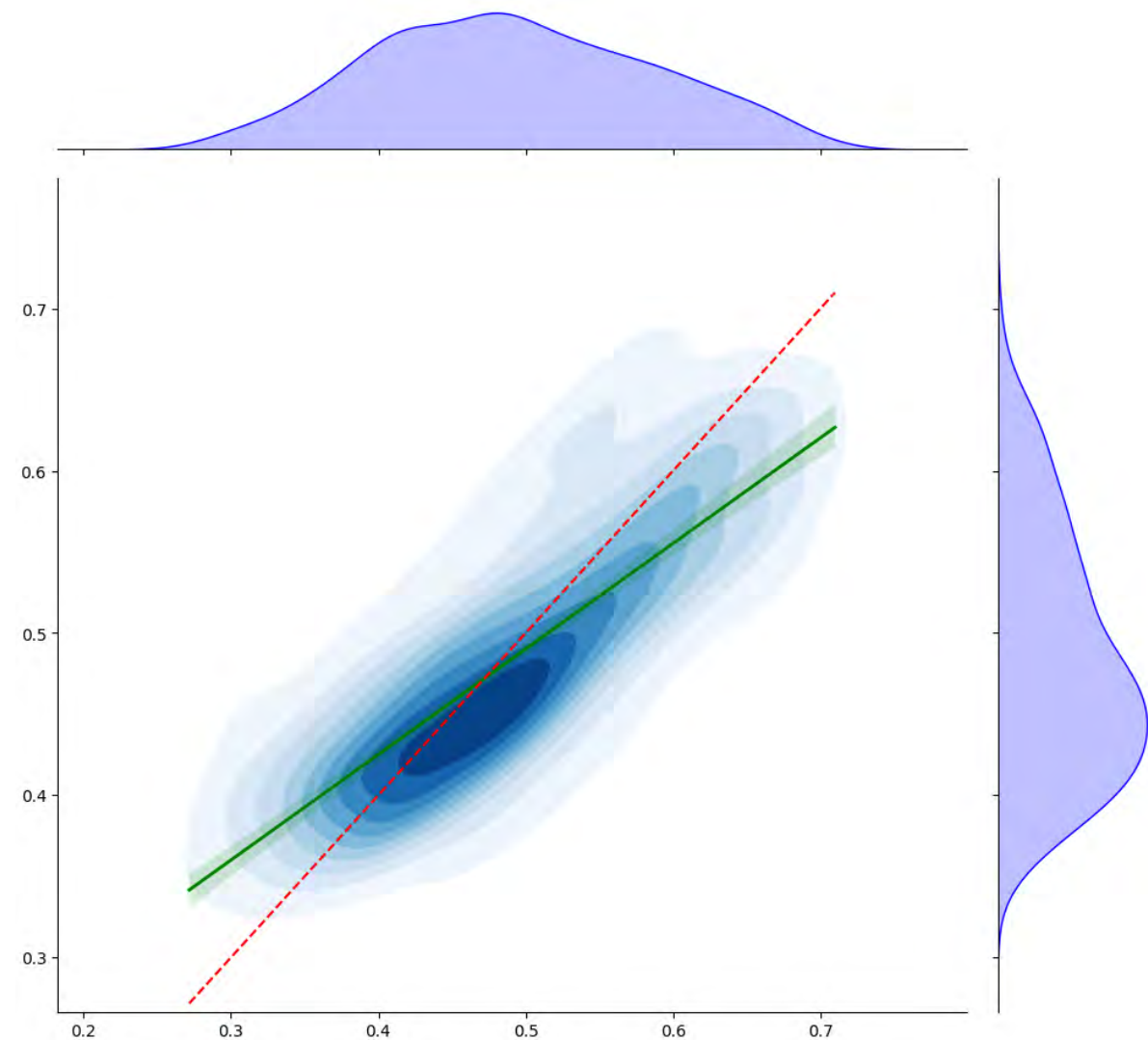
- ▶ A Modified U-Net with 9 hidden layers with ~ 27,000 weights to estimate have been developed



Scheme of the developed Modified U-Net

## Training and test results

- ▶ The Modified U-Net was trained on LDAS outputs and site characteristics from 2017 to 2022, validated on 2023, and tested on 2024 data.
- ▶ The model focuses on estimating LFMF for temperate deciduous forest, consistent with the studied species on studied sites.

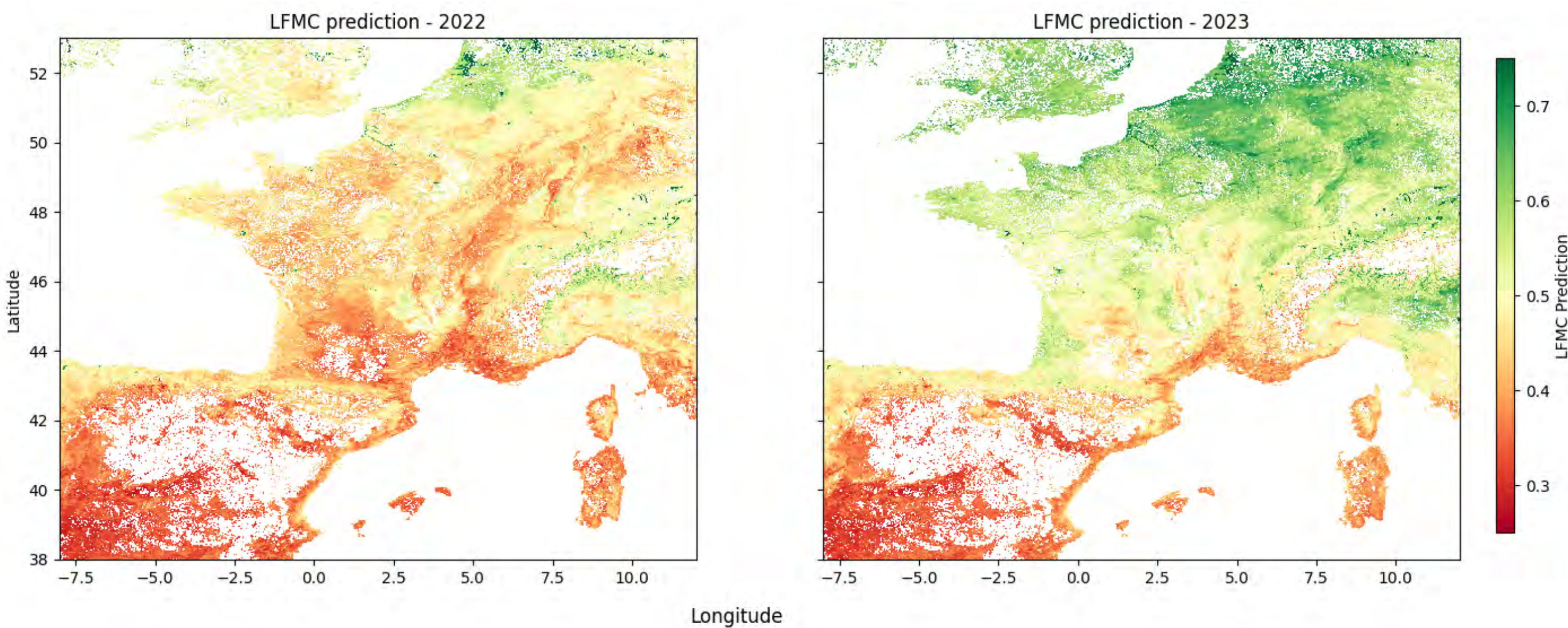


2D-histogram of the NN-prediction for the test dataset.

- ▶ We end up with the following scores : **RMSE** = 0.06, **KGE** = 0.73, **NSE** = 0.62, **R** = 0.79

## The use of the Modified U-Net to estimate LFMF's values over France

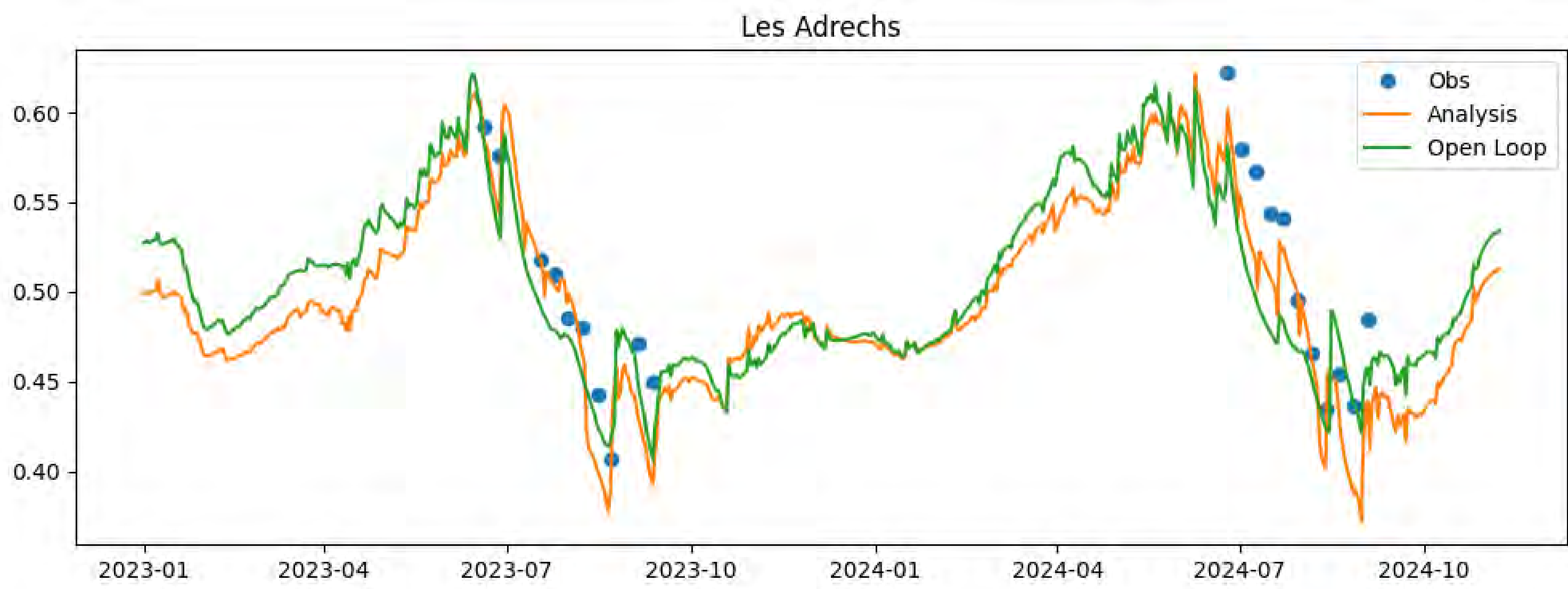
- ▶ The trained model was applied spatially over France on unseen data, demonstrating its ability to generalize and produce spatially coherent estimations of LFMF across diverse ecosystems.



Year-to-year variation of modelled LFMF on August 10th

## Impact of LAI assimilation in ISBA compared with observations

- ▶ The comparison highlights the importance of LAI assimilation in improving the LFMF estimation, especially during periods of strong vegetation dynamics.



## Conclusions

- ▶ Our Modified U-Net can be trained to simulate the LFMF dataset. We can make it simple enough to be used for the operational needs, but still efficient.
- ▶ Such high-resolution maps of LFMF are a brand new tool, as far as we know. But they still need to withstand their trial by fire.

## Bibliography

- [1] M. Yebra et al. Globe-lfmc 2.0, an enhanced and updated dataset for live fuel moisture content research. *Scientific Data*, 2024.
- [2] Pimont F. Dupuy J.L. et al. Martin-StPaul, N. Live fuel moisture content (lfmc) time series for multiple sites and species in the french mediterranean area since 1996. *Annals of Forest Science*, 2018.