SeasFire

Earth System Deep Learning for Seasonal Fire Forecasting in Europe

MOTIVATION

Fires are a major natural hazard, disrupting natural ecosystems, causing loss of lives, property, and infrastructure. It is crucial to understand and model the phenomenon at a seasonal scale, as it is expected to become more frequent and devastating in the future due to climate change.

Studies have shown that fire does not behave the same way between different areas and years, which means that fire exhibits a **spatio-temporal variability**.

Traditionally, this variability has been explained by simple statistical measurements or by using local variables derived from main fire drivers as input to tree-based ML models.

Current approaches, however, ignore the fact that different areas of the world are part of **one spatio-temporally interlinked system - the Earth System**.

THE SEASFIRE APPROACH

We explore spatio-temporal asynchronous links between pre-occurring, non-overlapping atmospheric conditions and European fire regimes, to predict seasonal burned areas in Europe.

We exploit two major advancements of our time: a) the availability of a vast amount of EO data with a good spatio-temporal resolution, representing the major fire drivers and the results of wildfires (burned areas, fire emissions) and b) the progress in Deep Learning, especially **Graph Neural Networks and Transformers** which can capture spatio-temporal interactions in the Earth system.

We develop an innovative prototype system that predicts **seasonal burned area sizes for Europe**, using global environmental variables, and we simulate their impact on local fire regimes.

What is the spatio-temporal contribution of the different fire drivers in the seasonal fire patterns in Europe and how do those fire drivers interact?

How much do teleconnections enable us to anticipate seasonal fire patterns with high confidence in comparison to merely climate forecasting strategies?

Can we use modern Deep Learning architectures to learn memory and lag effects in fire regimes and the possible teleconnections?

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IAASARS

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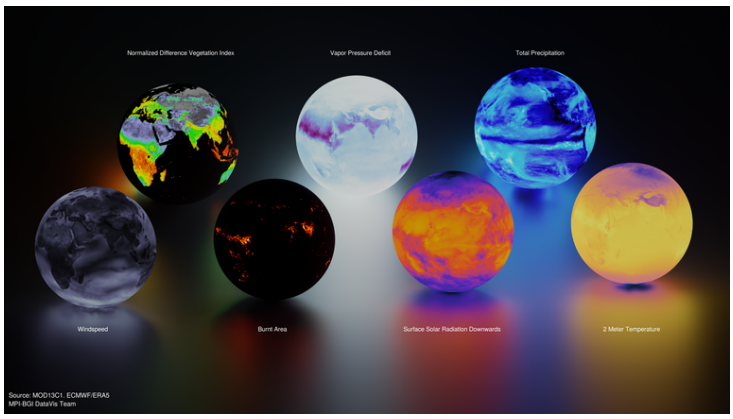
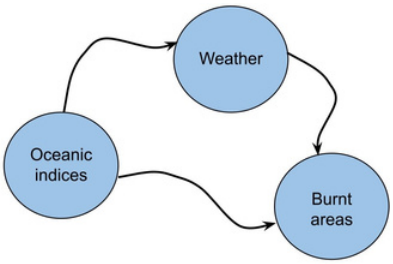
HAROKOPIO UNIVERSITY

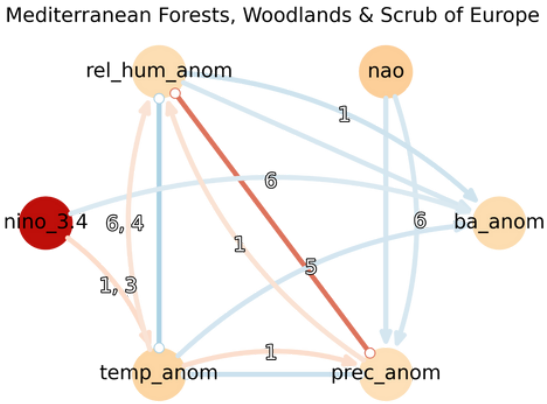
Max Planck Institute for Biogeochemistry

SEASFIRE DATACUBE

The SeasFire Cube is a global Analysis Ready Datacube designed for climate prediction tasks such as modelling burned areas of seasonal wildfires in Europe using geometric deep learning. It covers a large range of variables, many of which are atmospheric, and can also be used for global environmental modelling from 2001 to 2021 for tasks such as burned area modelling, or fire emissions forecasting.





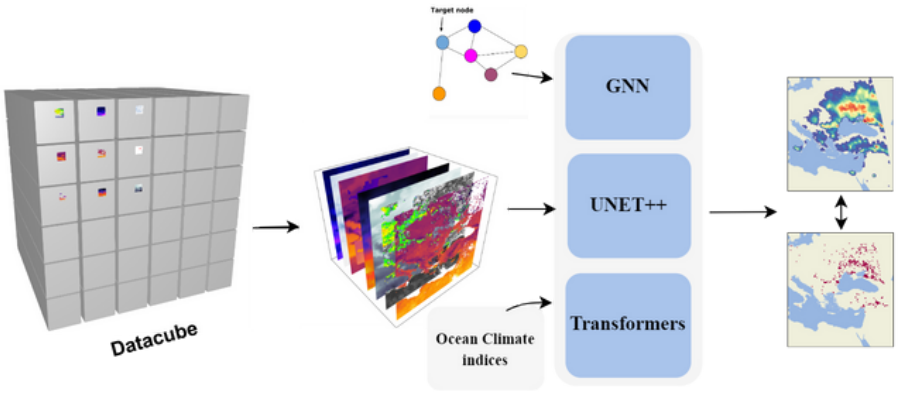


CAUSAL ANALYSIS

Using the SeasFire Cube, we conduct causal analysis to identify the major drivers of wildfires in Europe at a seasonal scale. This study reveals the complexity of interactions between the different fire drivers, and guides the development of machine learning models.

EARTH SYSTEM DEEP LEARNING

Although there have been successful applications of DL for Earth science, traditional architectures like plain CNNs that treat each image patch independently do not account for large-scale interactions in the Earth System, like teleconnections and memory effects. SeasFire goes beyond demonstrating the use of Graph Neural Networks (GNNs) and Transformers that can better capture such interactions.



Harmonized Dataset

SeasFire cube can be a test bed for wildfire-related models at sub-seasonal to seasonal scales

Deep Learning for wildfire forecasting

Deep Learning can efficiently simulate wildfires and increase our ability to forecast global burned areas

Earth System Deep Learning

Enhances performance
Improves our understanding of Earth-scale processes

CONTACT US

Coordinator: Ioannis Papoutsis
National Observatory of Athens
e-mail: ipapoutsis@noa.gr

RESOURCES

Website: https://seasfire.hua.gr/
Datacube: https://doi.org/10.5281/zenodo.7108392
Tutorial: https://github.com/SeasFire/seasfire-datacube