Deep Learning for Wildfire Danger Forecasting

Ioannis Prapas

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European Commission

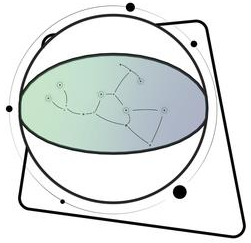
Deep Learning for Wildfire Danger Forecasting

Simplifying Earth Intelligence with manteo.ai

Ioannis Prapas

1. Founder of manteo.ai
2. PhD @ Orion Lab NTUA + University of Valencia

manteo.ai



orion lab

RSLab
Remote Sensing Laboratory
National Technical University of Athens

ISP · Image & Signal Processing
Universitat de València

Our work in general

We work with big **Earth Observation data** and **Artificial Intelligence research** to have a positive impact on the society and the environment

- **Forecasting**: Wildfire danger @ short-term to seasonal scales
- **Early warning**: Volcanic unrest detection, climate extremes
- **Damage assessment**: Floods, landslides, burnt area mapping
- **Planning** & preparedness: Fire spread

Join us in Athens: 16-20 March 2026

orion lab
AI & Earth Observation Research

RSLab
Remote Sensing Laboratory
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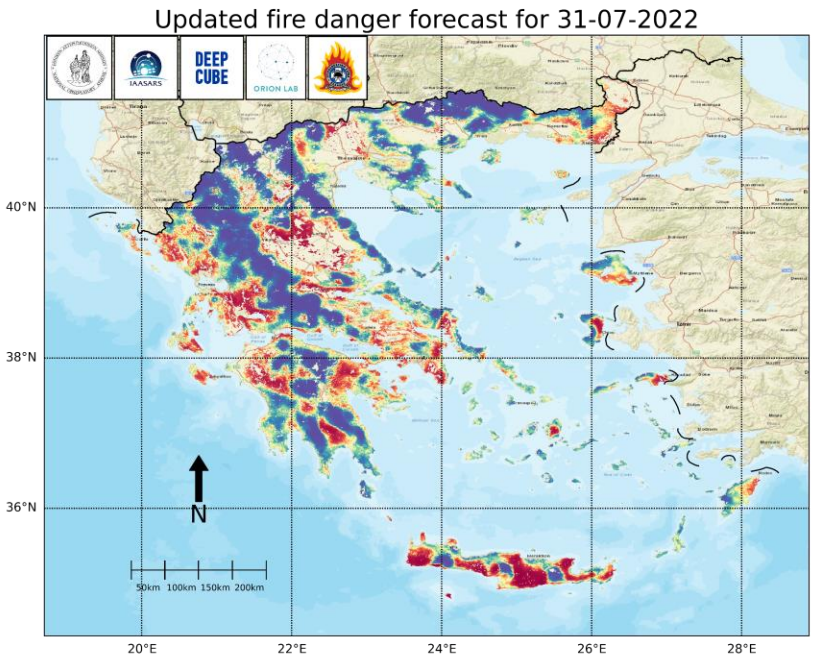
European Laboratory for Learning and Intelligent Systems

Agenda Today

Data-driven wildfire danger forecasting



Simplifying Earth Intelligence

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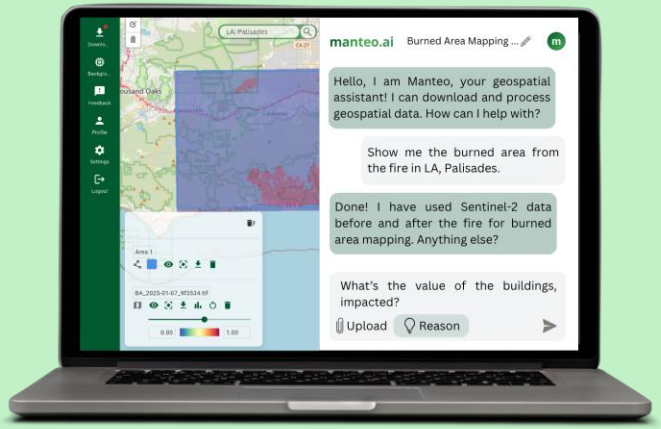


Data-driven wildfire danger forecasting

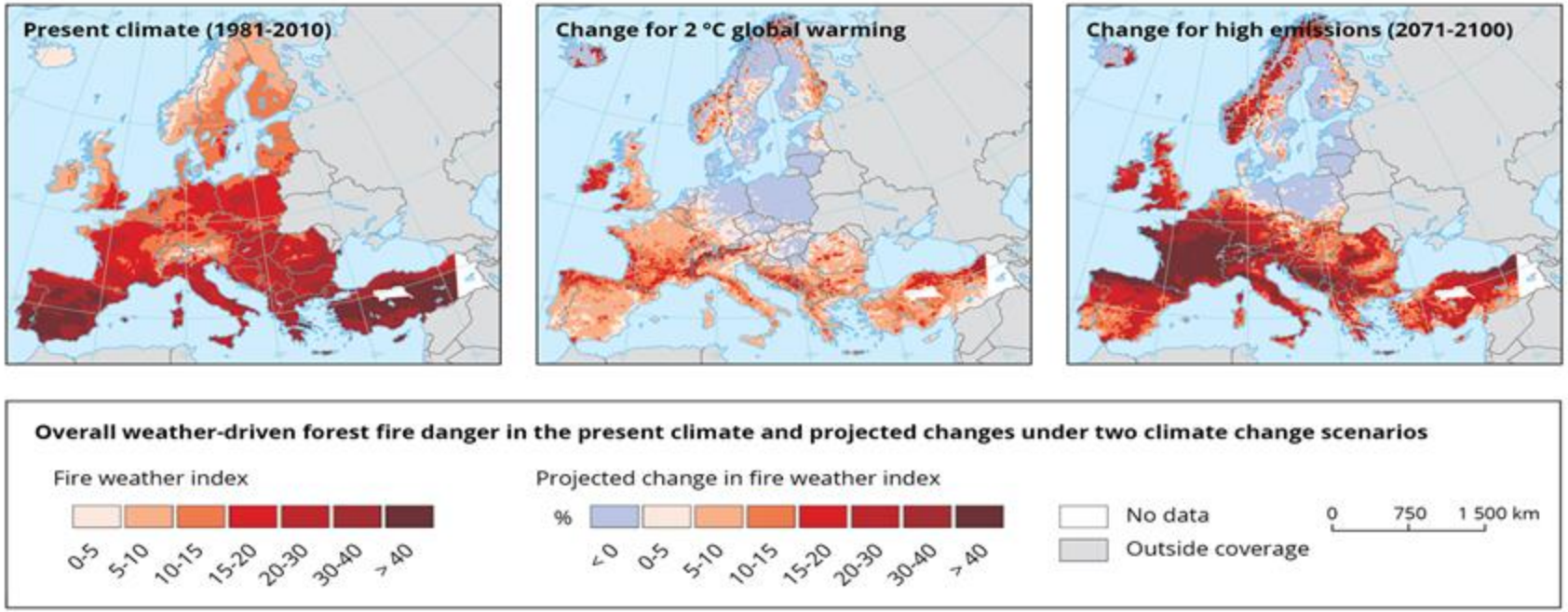
Task Formulation → Evaluation → Explainability → Operations

Motivation

Wildfires can be destructive

Short-term forecasting can help mitigation plans

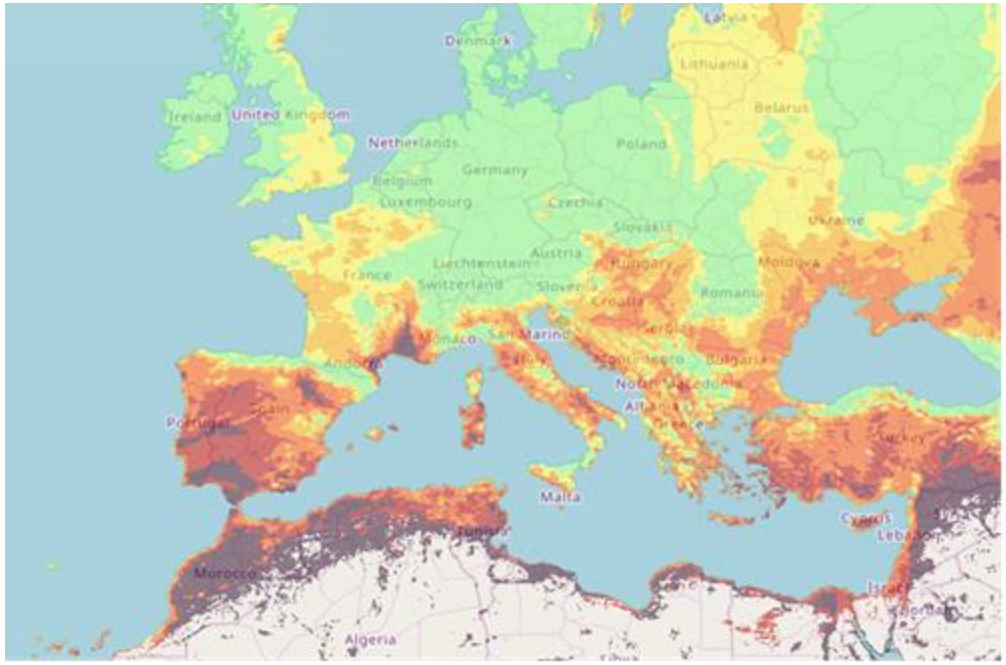
Climate change aggravates wildfires



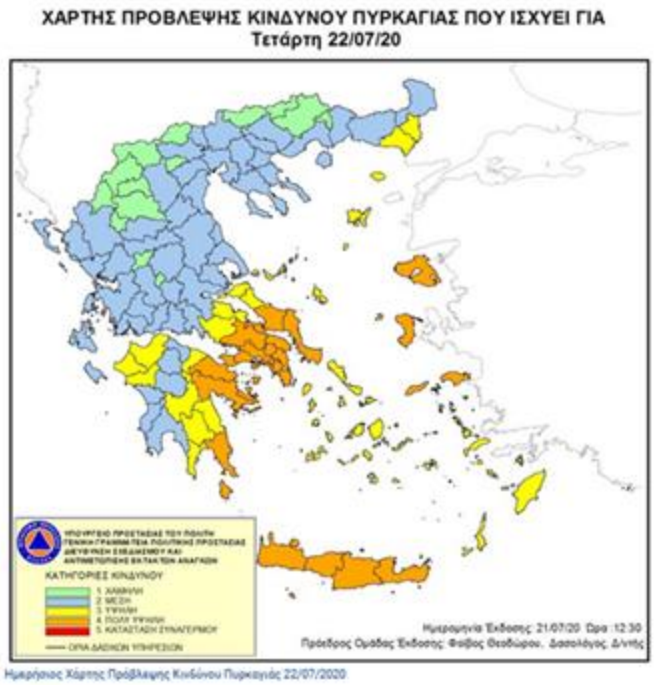
Fire danger in Europe under projected climate. Source: De Rigo, Daniele, et al. Forest fire danger extremes in Europe under climate change: variability and uncertainty. (2017)

Important to accurately forecast wildfire danger

Current Status



Source: EFFIS fire danger forecast for July 16th 2020
https://effis.jrc.ec.europa.eu/about-effis/

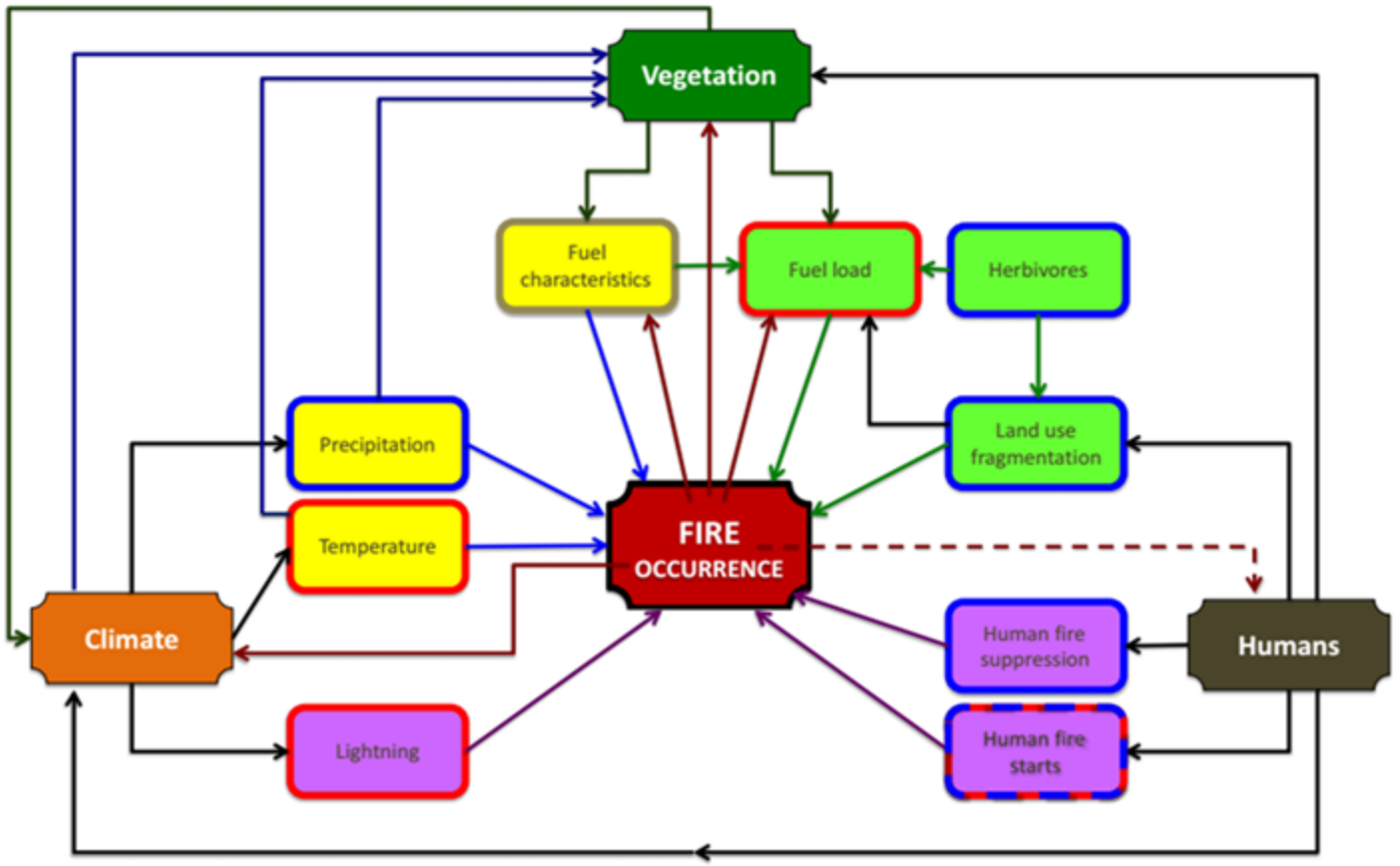


Fire danger maps from Greek Civil Protection

Can we do better?

Challenge

Fires are the result of **complex interactions** between humans, climate, vegetation



Fire Drivers. *Source: Hantson et al. "The status and challenge of global fire modelling" (2016)*

Idea: Use Machine Learning to learn directly from data

Defining Fire Danger

What is fire danger?

“Fire danger assesses the conditions that allow a fire to ignite and spread.” Pettinari, M. Lucrecia, and Emilio Chuvieco. "Fire danger observed from space." (2020)

FireCube - Data Collection and Harmonization

Variables

Meteo (ERA5-Land): Temperature, Wind speed & direction, Precipitation, Relative Humidity (9km)

Satellite (MODIS): Land Temperature, NDVI/EVI, LAI/FPAR, Evapotranspiration

Soil moisture (European Drought Observatory)

Topography (EU-DEM): Elevation, Slope, Aspect

Land Cover (Corine)

Population Density (WorldPop)

Roads Density (OpenStreetMap)

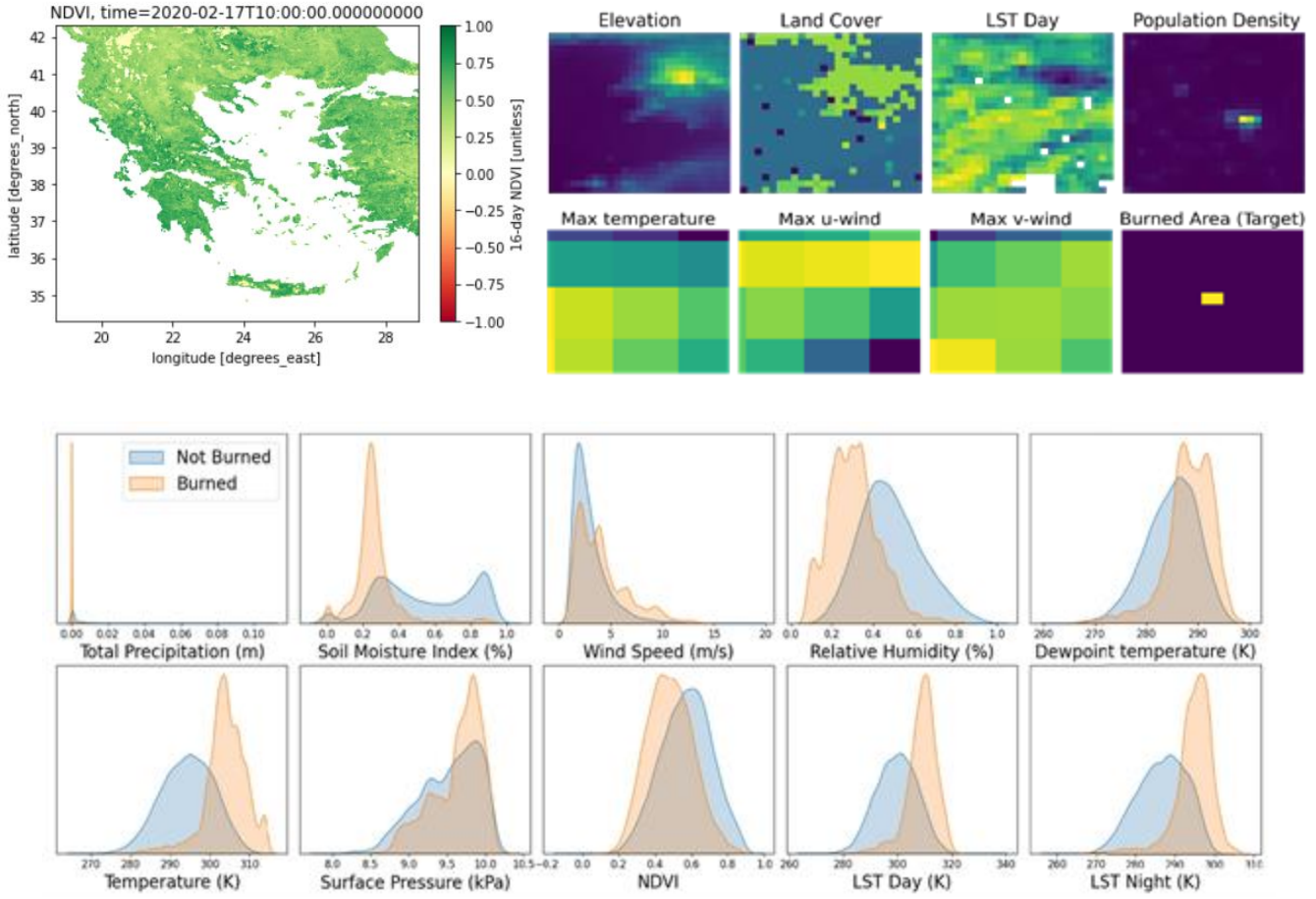
Burned areas (EFFIS)

Harmonization

Resolution: 1km x 1km x 1day

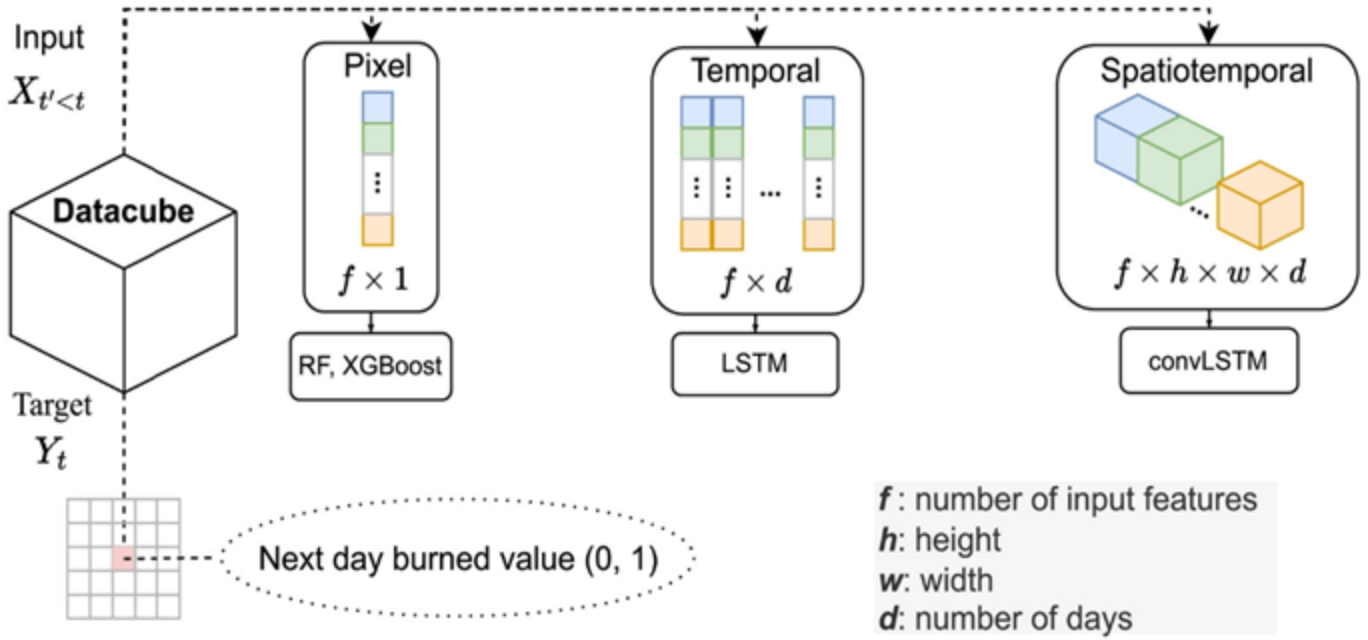
Spatial Extent: Greece and eastern Mediterranean

Temporal Extent: 2009-2021



FireCube: A Daily Datacube for the Modeling and Analysis of Wildfires in Greece (1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.6475592

Experimental Setup




Geophysical Research Letters

Research Letter | Open Access

Wildfire Danger Prediction and Understanding With Deep Learning

Spyros Kondylatos, Ioannis Prapas, Michele Ronco, Ioannis Papoutsis, Gustau Camps-Valls, María Piles, Miguel-Ángel Fernández-Torres, Nuno Carvalhais


arXiv > cs > arXiv:2111.02736

Computer Science > Machine Learning

[Submitted on 4 Nov 2021]

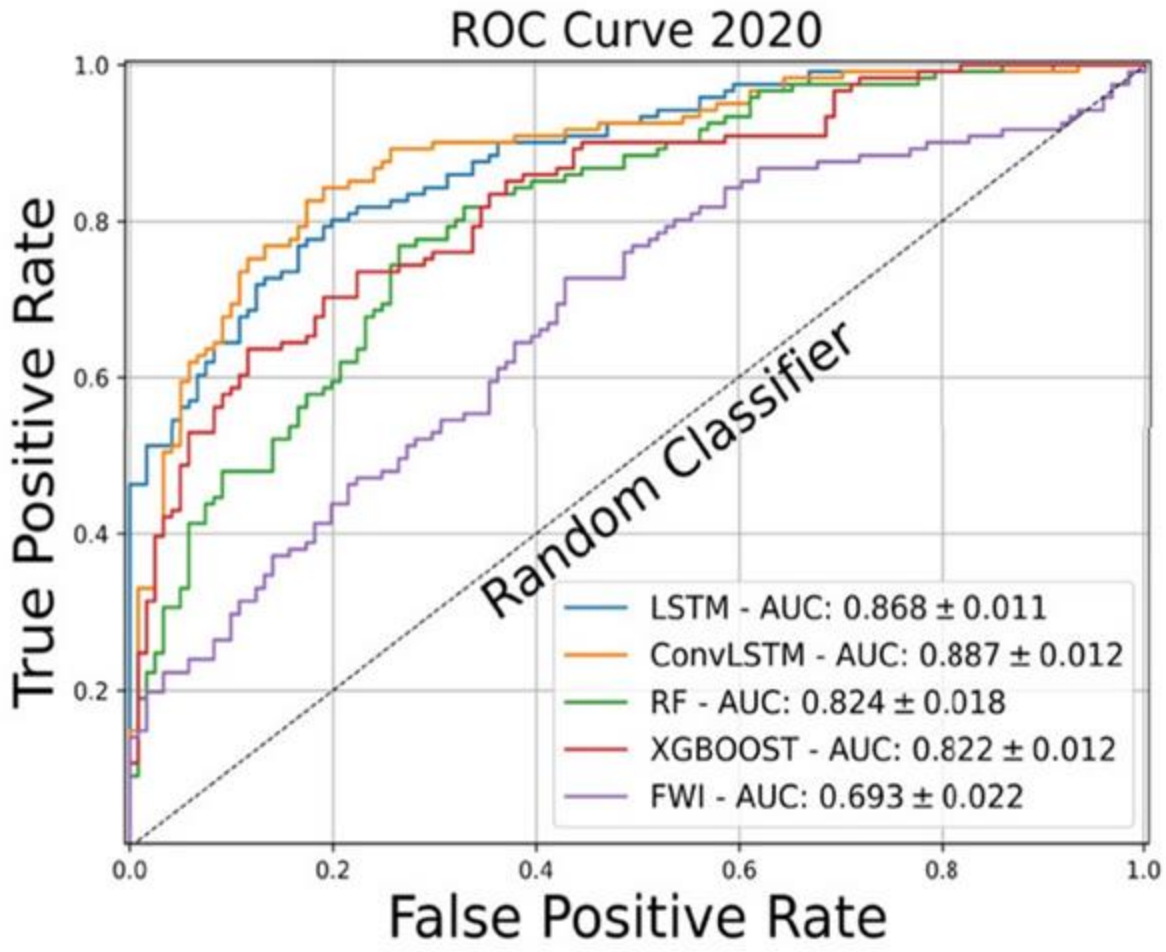
Deep Learning Methods for Daily Wildfire Danger Forecasting

Ioannis Prapas, Spyros Kondylatos, Ioannis Papoutsis, Gustau Camps-Valls, Michele Ronco, Miguel-Ángel Fernández-Torres, Maria Piles Guillem, Nuno Carvalhais

Wildfire forecasting is of paramount importance for disaster risk reduction and environmental sustainability. We approach daily fire danger prediction as a machine learning task, using historical Earth observation data from the last decade to predict next-day's fire danger. To that end, we collect, pre-process and harmonize an open-access datacube, featuring a set of covariates that jointly affect the fire occurrence and spread, such as weather conditions, satellite-derived products, topography features and variables related to human activity. We implement a variety of Deep Learning (DL) models to capture the spatial, temporal or spatio-temporal context and compare them against a Random Forest (RF) baseline. We find that either spatial or temporal context is enough to surpass the RF, while a ConvLSTM that exploits the spatio-temporal context performs best with a test Area Under the Receiver Operating Characteristic of 0.926. Our DL-based proof-of-concept provides national-scale daily fire danger maps at a much higher spatial resolution than existing operational solutions.

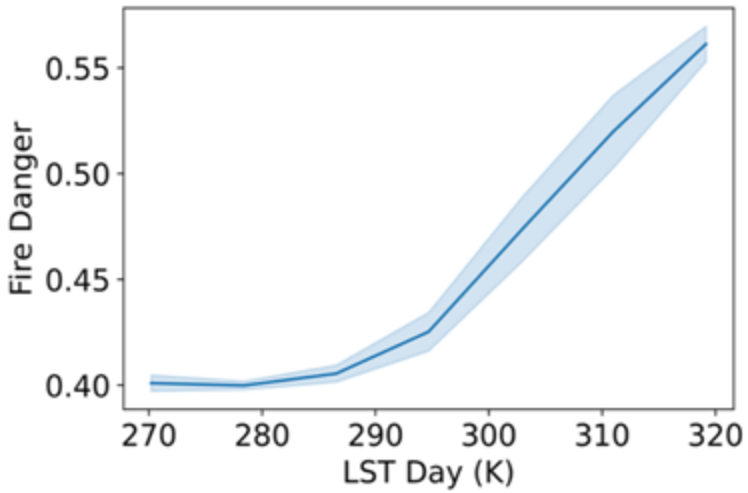
Comments: Accepted to the workshop on Artificial Intelligence for Humanitarian Assistance and Disaster Response at the 35th Conference on Neural Information Processing Systems (NeurIPS 2021)

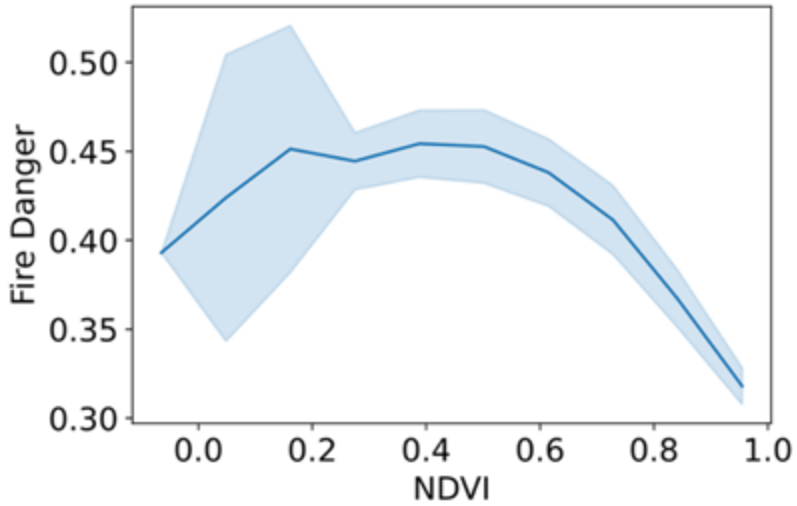
Evaluation

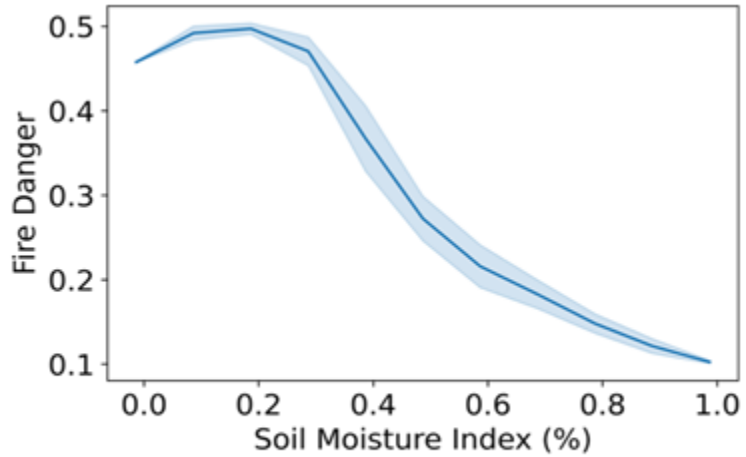


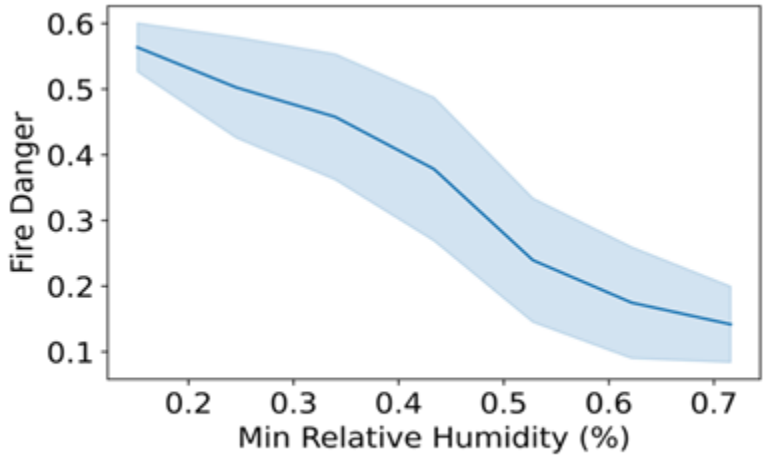
But what did the models learn?

Explainability: partial dependencies

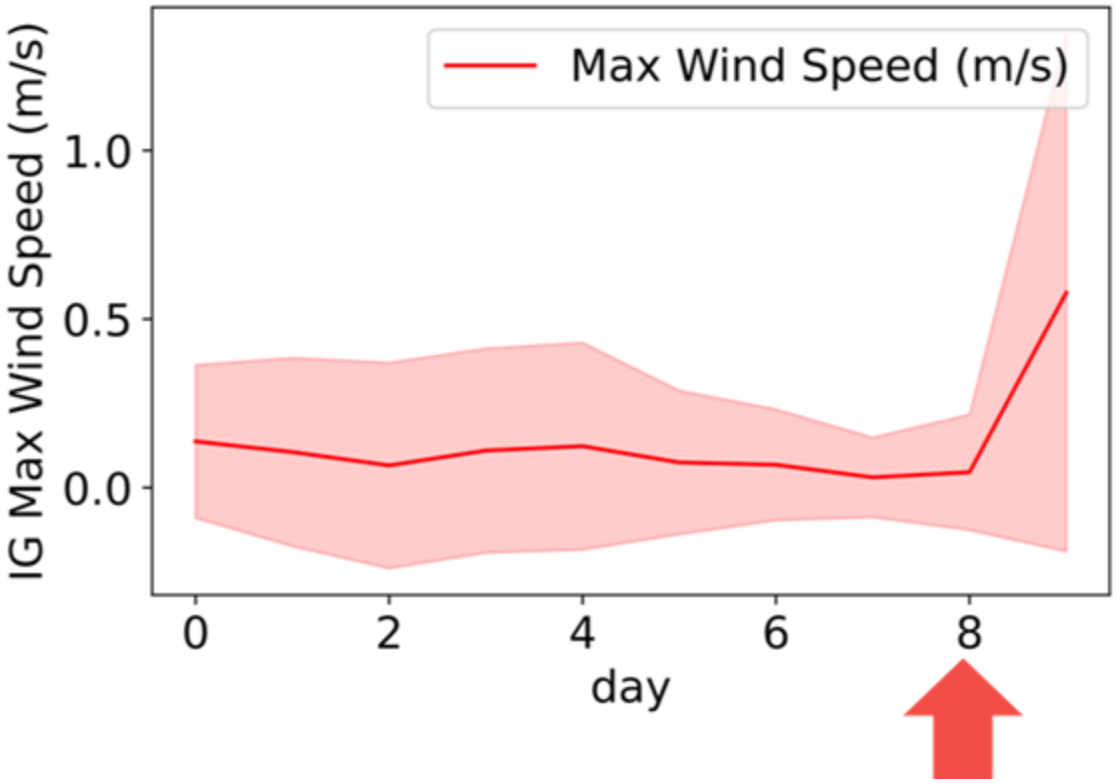






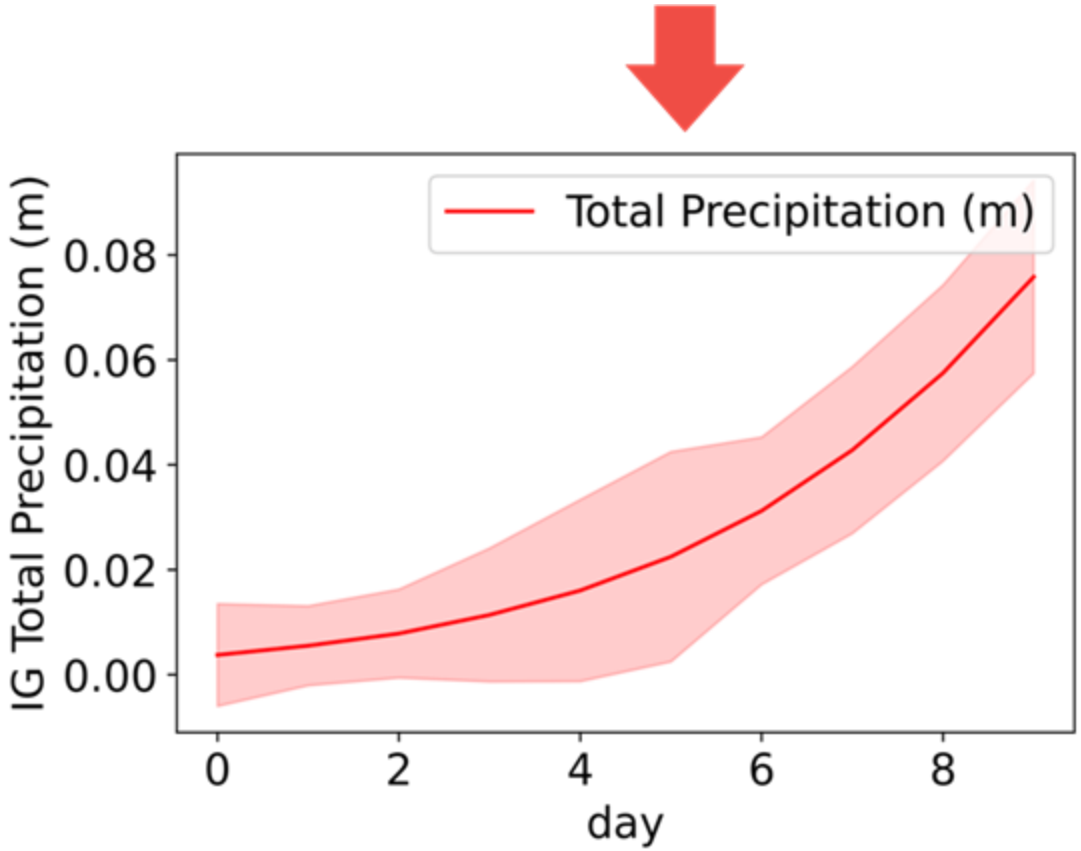


Explainability: temporal contribution



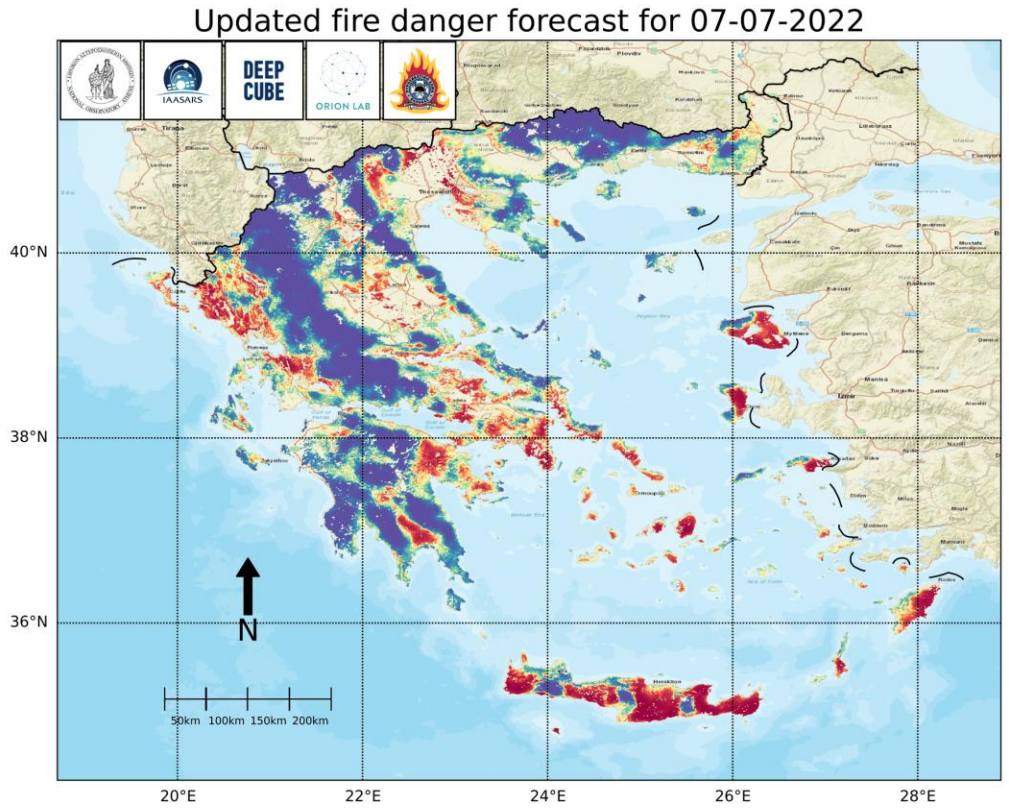
Sudden-onset activation: instantaneous effects

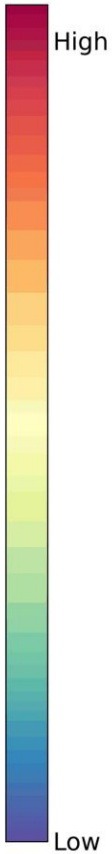
Slow-onset activation: accumulation effects

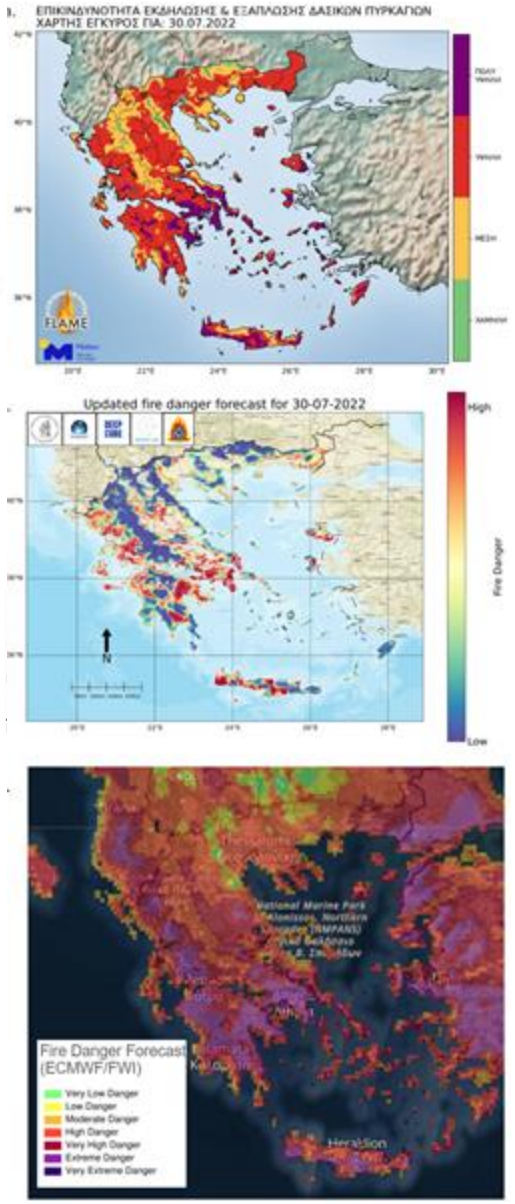


Research → Operations

- We apply this setting with real-time data
- Generally higher resolution and precision than fire danger indices
- Evaluation from officials

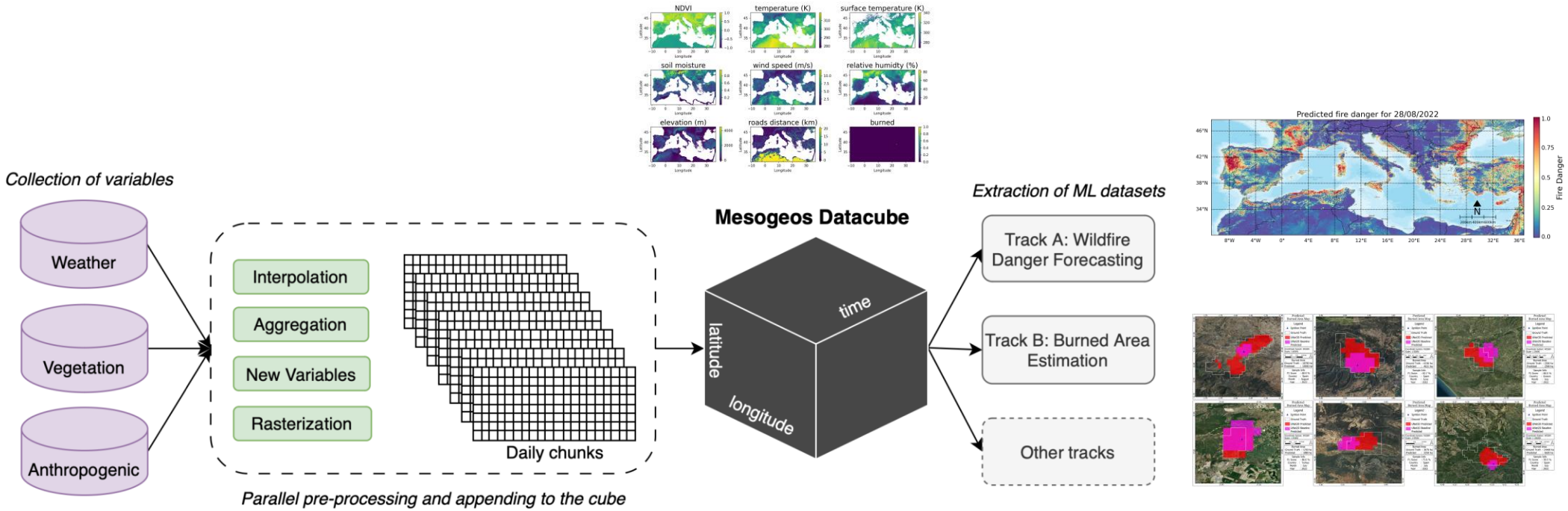






Deployed service working since 2022
https://orion-watch.space.noa.gr/FireWatchGreece/ui/pages/map

Expansion to the Mediterranean



S. Kondylatos, I. Prapas et al. (2025) NeurIPS 2023. “ **Mesogeos: A multi-purpose dataset for data-driven wildfire modeling in the Mediterranean**”

Main takeaways

- Machine Learning can help improve fire danger forecasting
- Open data and code essential for collaboration
- Crucial to involve stakeholders moving from research to operations

https://orionlab.space.noa.gr/
https://github.com/orion-ai-lab

Manteo AI

Simplifying Earth Intelligence with Language Models + Geospatial AI

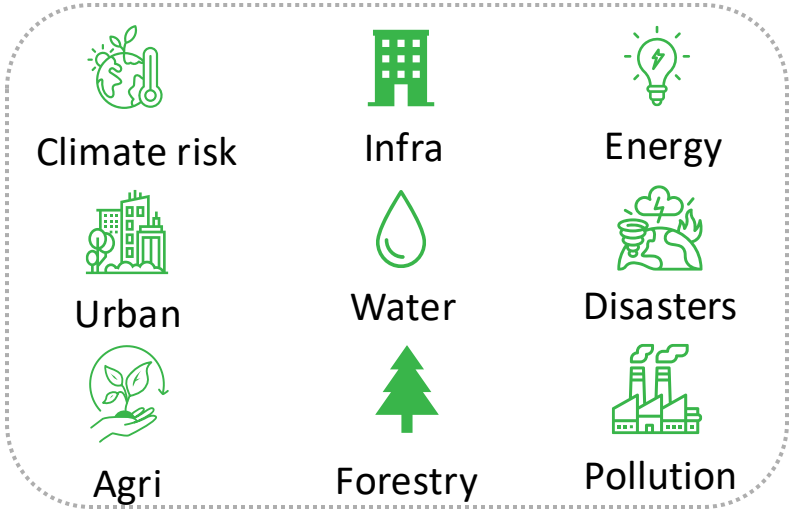
The Problem we tackle

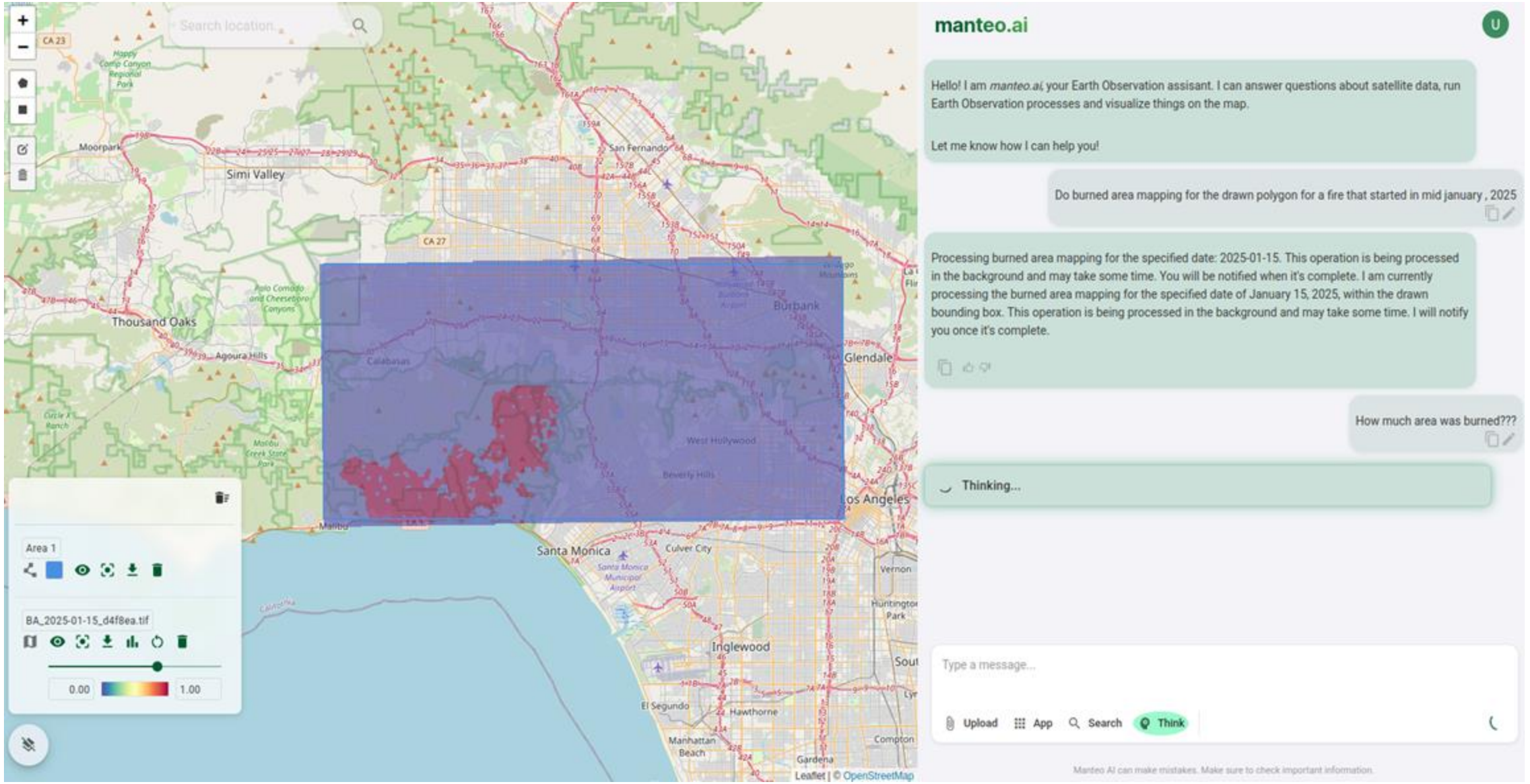
Non-expert users need insights from **massive geospatial data**, involving **complex processing**

Big Data

Diverse Applications

Complex Infra





Manteo AI Assistant - Users ask **questions** and get back **insights**

manteo.ai

Manteo AI

Assistant

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Reporter

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Earth Insights for everyone

Looking for:

- Early Adopters
- Interesting Use Cases
- Partnerships and Pilots

Join us to build AI that understands the Earth