LIVE TWIN
AEROSOLS
FDL EUROPE
2022

AEROSOLS

FDL 2022 | Technical Showcase
Thursday 15 September 2022

esa

Aerosols Team

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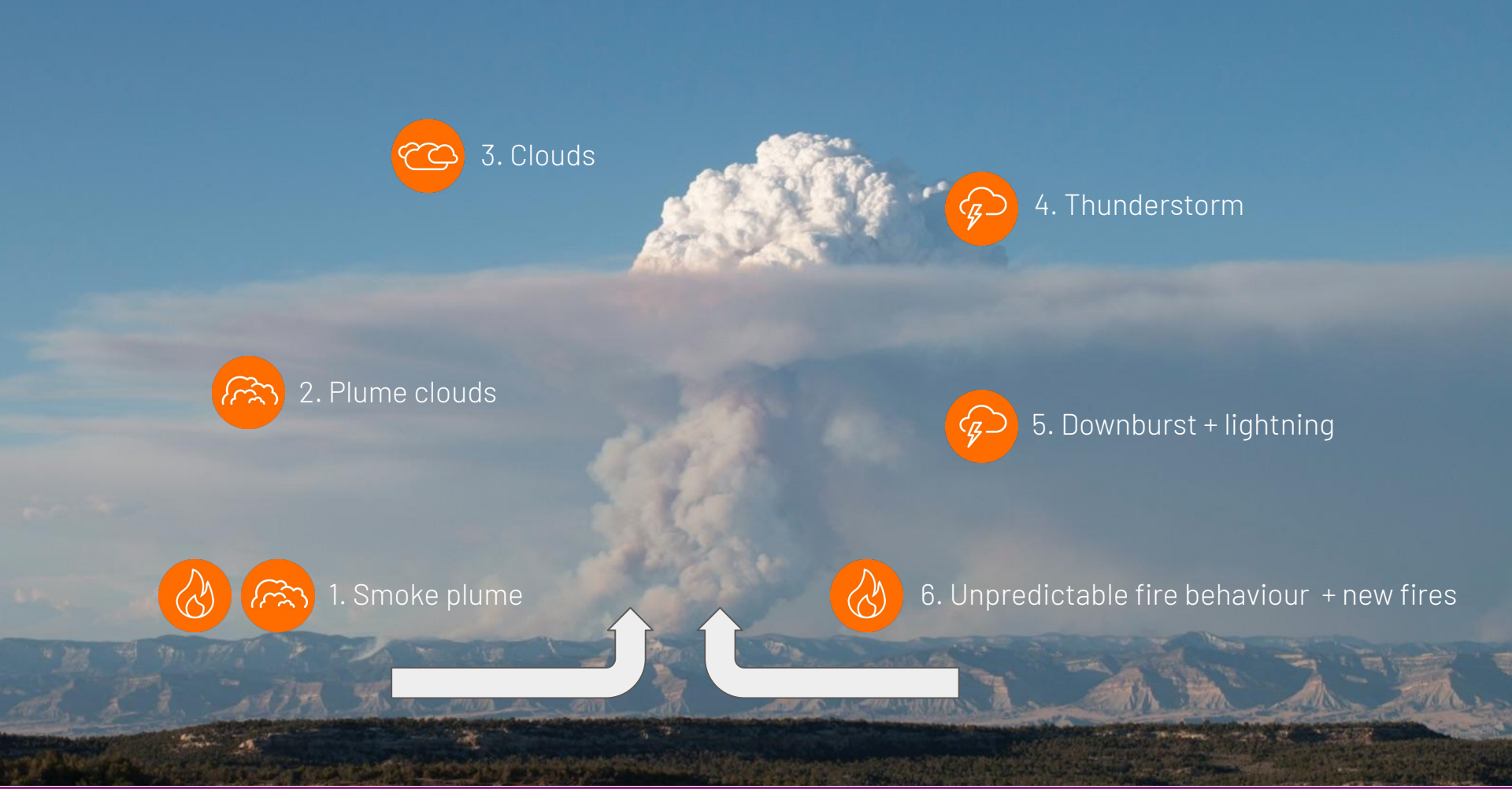
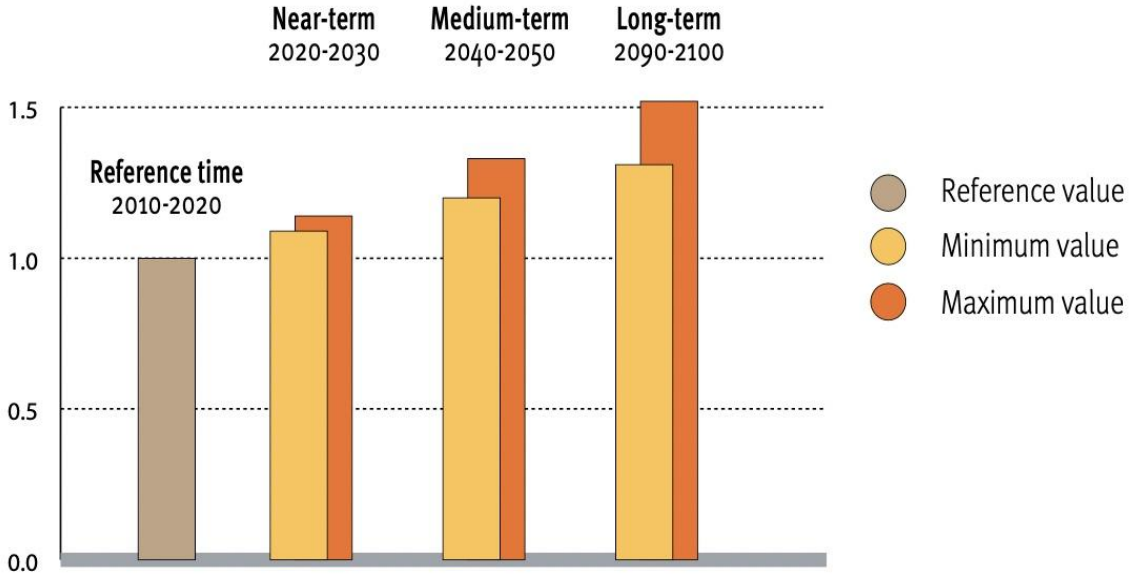

3. Clouds
4. Thunderstorm
2. Plume clouds
5. Downburst + lightning
1. Smoke plume
6. Unpredictable fire behaviour + new fires

Introduction

Global change in wildfire events



Source: Douglas I. Kelley, UK Centre for Ecology and Hydrology

Identified Needs

Strategic containment
+ evacuation

Which wildfires
are risky?

Predict PyroCb

Pyrocast

Machine Learning for PyroCb Forecasting

1

PyroCb Database

2

Forecasting Model

3

Discovery Framework

Tools, Compute, Software Environment

python™

Google Cloud Platform

Database libraries

- satpy, zarr, xarray
- Copernicus Data Store API
- Apache Beam and Dataflow

Machine learning libraries

- PyTorch for CNNs and auto-encoders
- Scikit Learn for random forests and metrics

Zarr

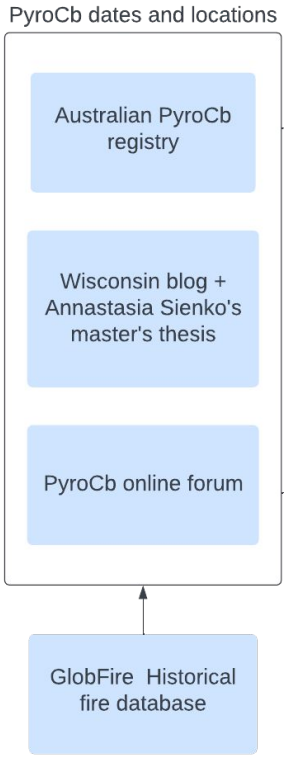
xarray

Apache Beam

PyTorch

scikit learn

Pyrocast | Database

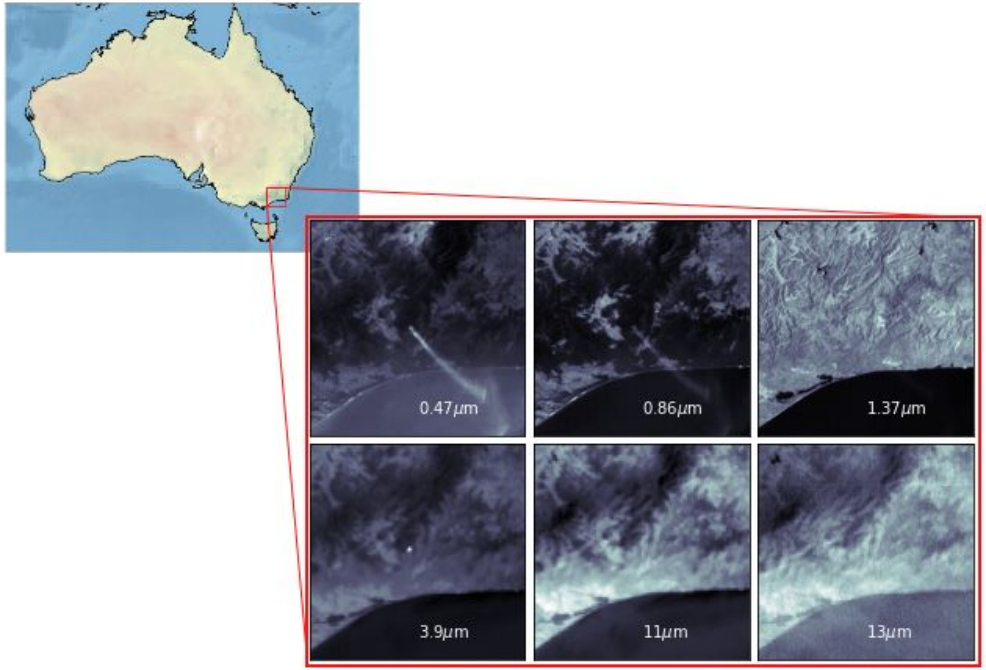


Pyrocast | Database

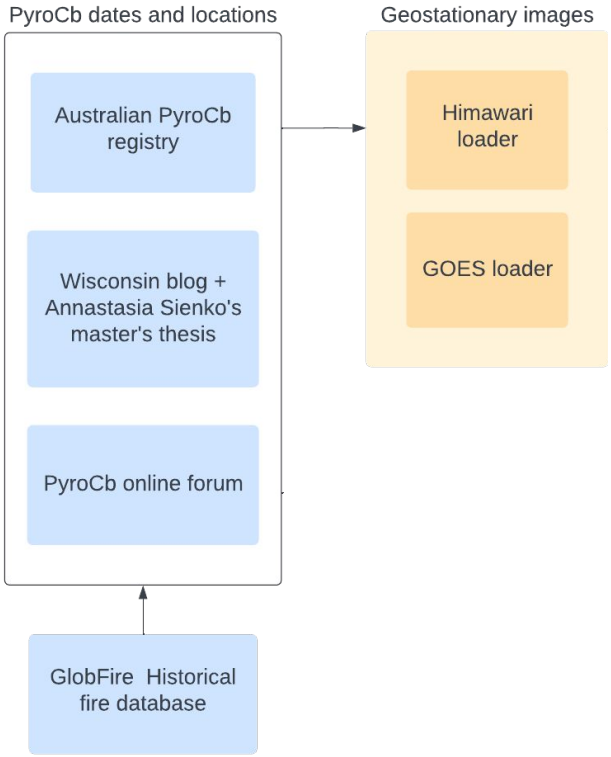
PyroCb dates and locations

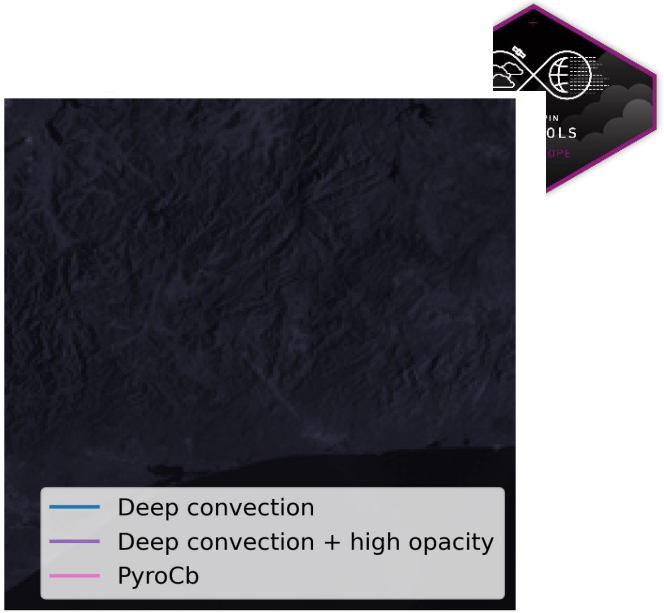
- Australian PyroCb registry
- Wisconsin blog + Annastasia Sienko's master's thesis
- PyroCb online forum

GlobFire Historical fire database

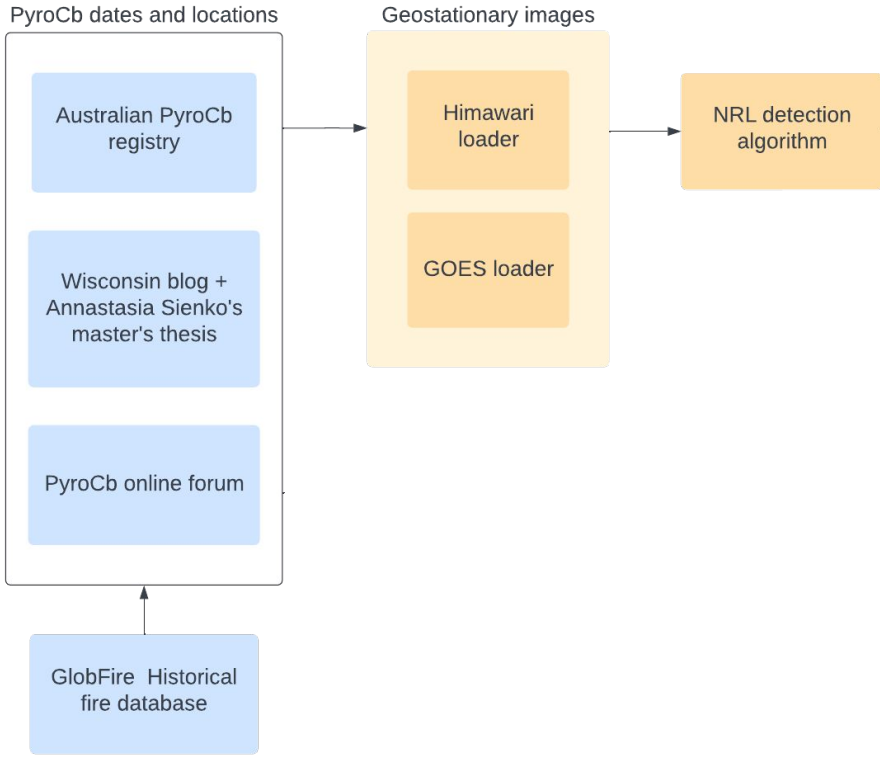


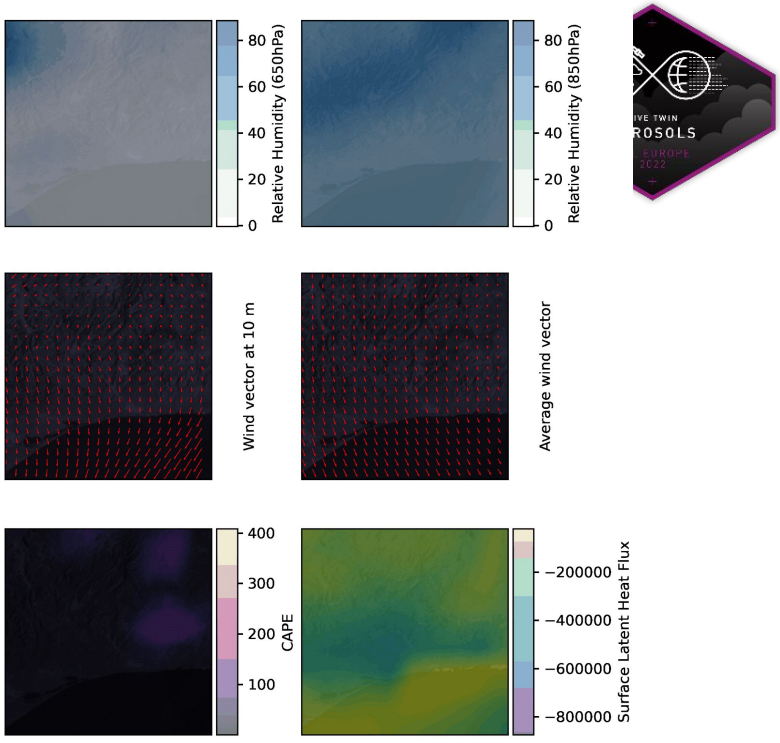
Pyrocast | Database



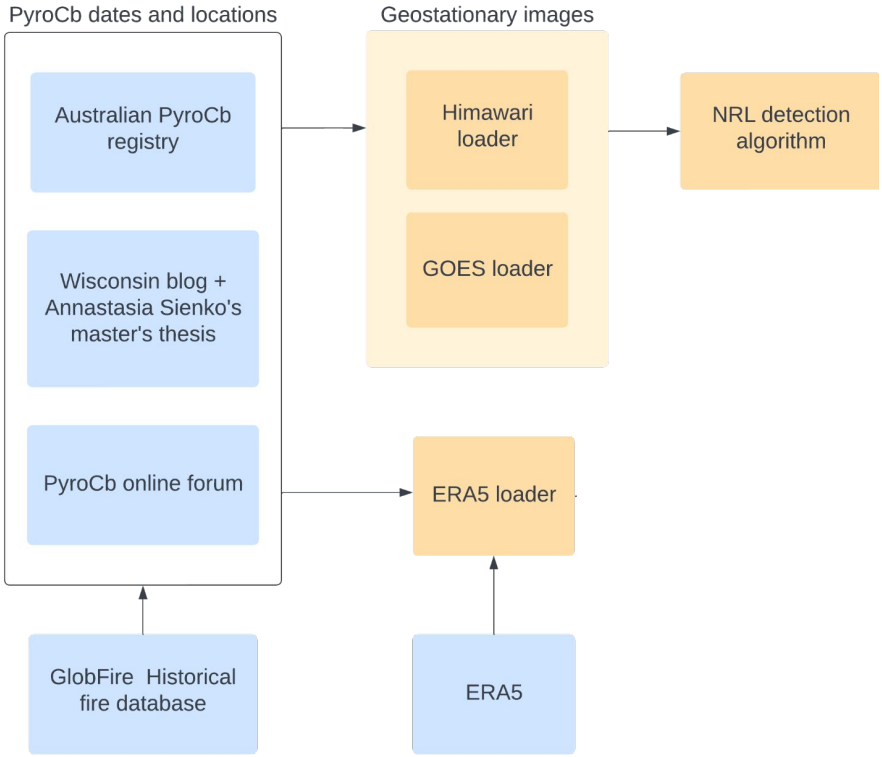


Pyrocast | Database



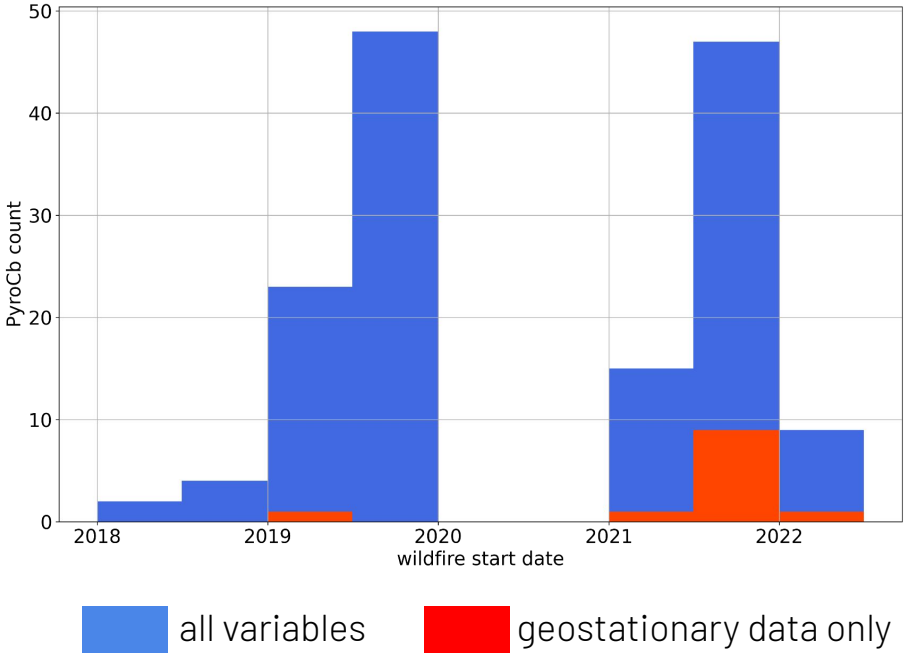


Pyrocast | Database



Pyrocast | Database

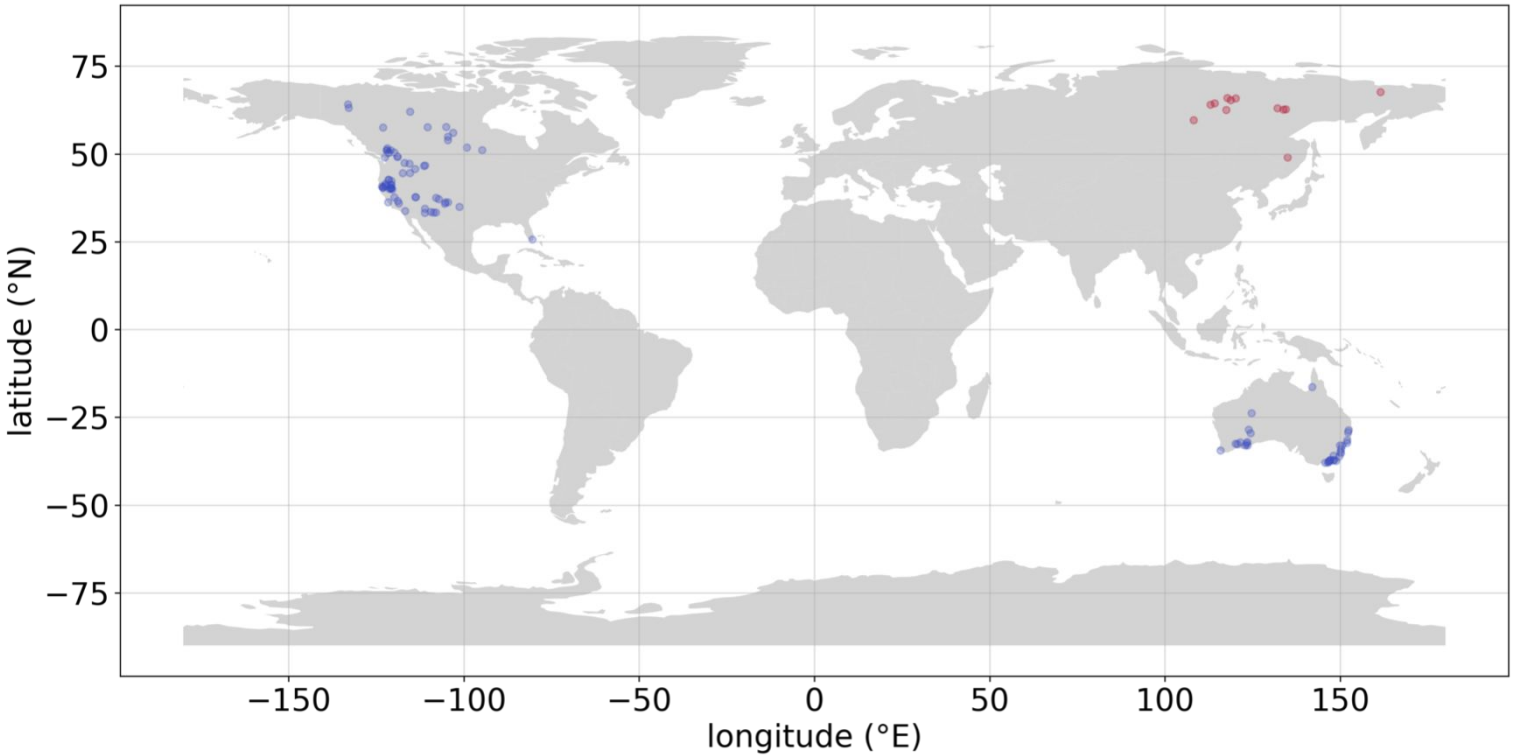
- First global PyroCb database
- 148 PyroCb ⇔ 111 wildfires
- Over 18k hourly observations
- 6 wavelength channels
- 19 meteorological and fuel variables
- Science and ML ready



Pyrocast | Database

all variables

geostationary data only



Pyrocast | Forecasting Model

Three learning tasks:

1. Detection
2. 6-hour forecast
3. 6 hour forecast with weather oracle

Three models:

1. Random Forests
2. CNN
3. Autoencoder-pretrained CNN

Three input sets:

1. Geostationary
2. Meteorological
3. Geostationary + meteorological

Pyrocast | Forecasting Model

These tasks, models and inputs are aimed at answering:

Can we develop **detection** algorithm to label more data with?

Is **imagery or meteorological** information more **important** for forecasting?

Can we boost forecast by using **weather forecast** as input?

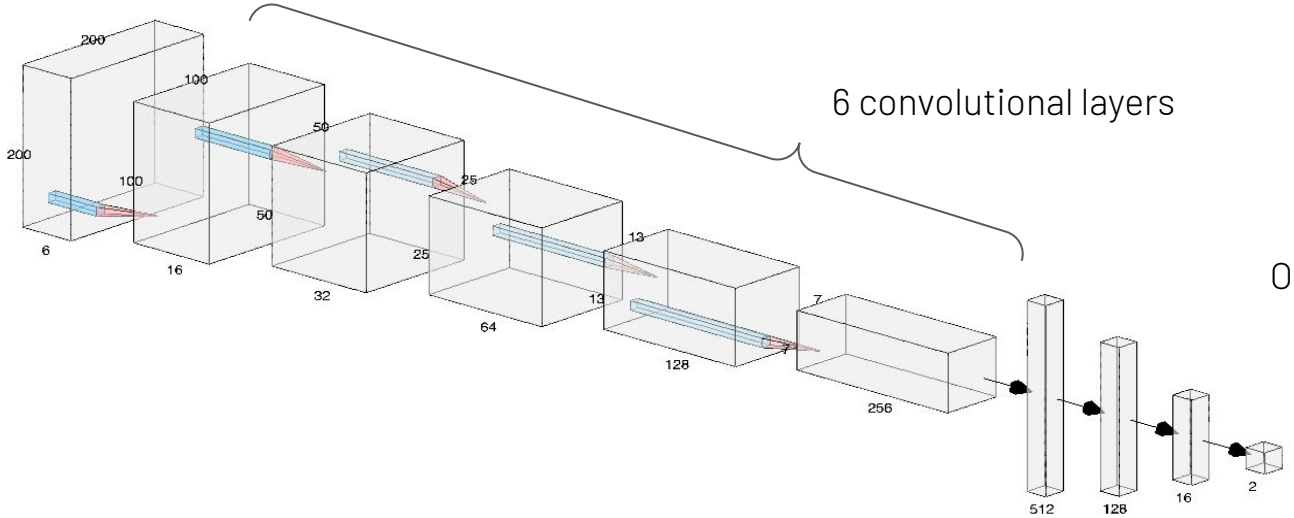
Is important information encoded **spatially**?

Do the models perform differently depending on the **initial state** of the wildfire ? ie. if a pyroCb precursor already exists.

Pyrocast | Forecasting Model

Inputs:

+ Geostationary images
+ Meteorological variables



Output:

+ binary classification

Pyrocast | Forecasting Model

Preprocessing

Task	# of Events	# of Observations
Detection	84	13,845
Forecast Oracle	83	6,919
Forecast	83	6,919

Pyrocast | Forecasting Model

Data splitting

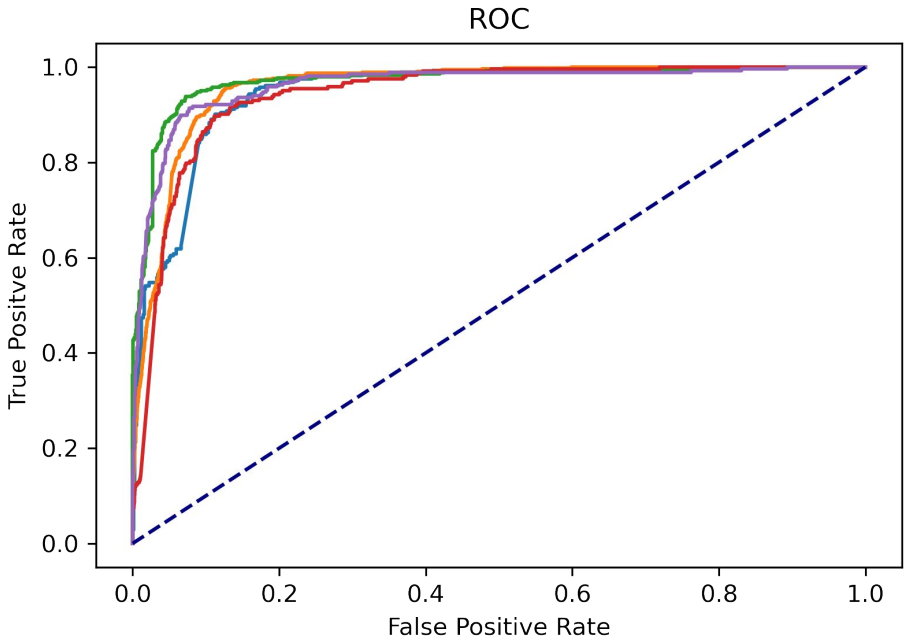
Task	Detection		Forecast Oracle		Forecast	
Cluster/Fold	**# of Events**	**# of snapshot obs.**	**# of Events**	**# of snapshot obs.**	**# of Events**	**# of snapshot obs.**
1	17	3,341	17	1,178	17	1,178
2	17	1,992	17	1,208	17	1,208
3	17	2,130	17	1,371	17	1,371
4	16	3,293	16	1,166	16	1,166
5	17	3.089	16	1,996	16	1,996

Pyrocast | Forecasting Model

Detection

	Features included				
Model	**gs**	**w3**	**gs + w3**	**w19**	**gs + w19**
RF	0.95	0.81	0.95	0.85	0.95
CNN	0.94	0.71	0.96	NA	NA
AE-CNN	0.97	0.73	**0.97**	NA	NA

Average test AUC across 5 folds

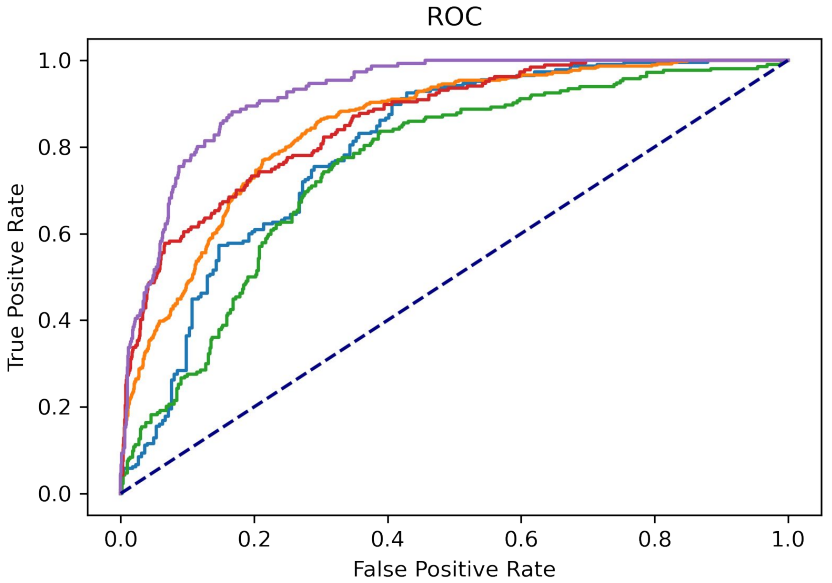


Pyrocast | Forecasting Model

Forecasting

	Features included				
Model	**gs**	**w3**	**gs + w3**	**w19**	**gs + w19**
RF	0.76	0.76	0.81	0.81	**0.84**
CNN	0.59	0.71	0.68	NA	NA
AE-CNN	0.65	0.7	0.74	NA	NA

Average test AUC across 5 folds

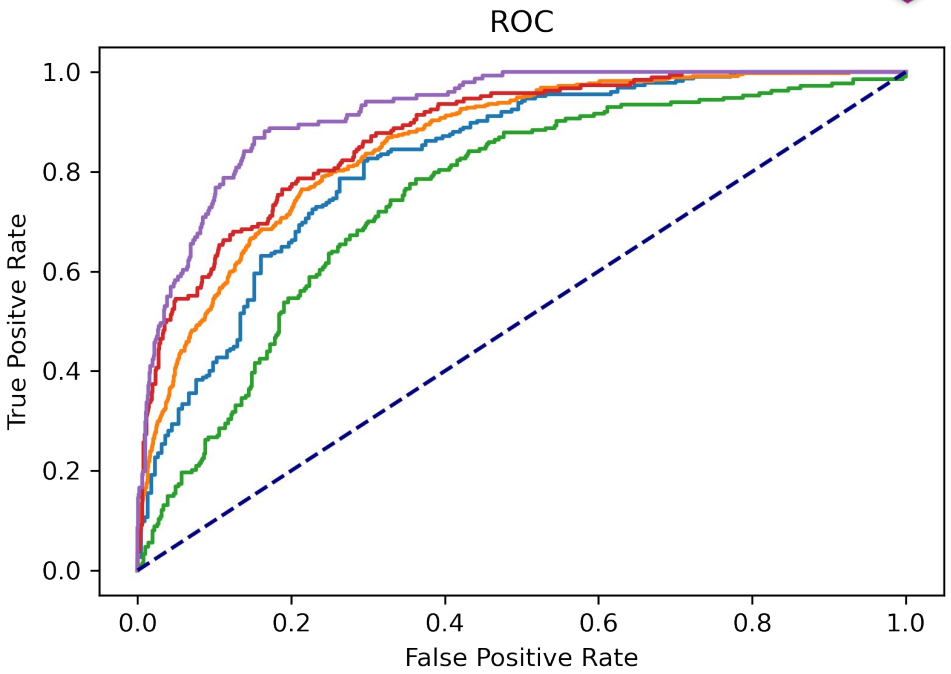


Pyrocast | Forecasting Model

Forecasting - oracle

	Features included				
Model	**gs**	**w3**	**gs + w3**	**w19**	**gs + w19**
RF	0.76	0.80	0.83	0.83	**0.85**
CNN	0.59	0.71	0.65	NA	NA
AE-CNN	0.65	0.72	0.74	NA	NA

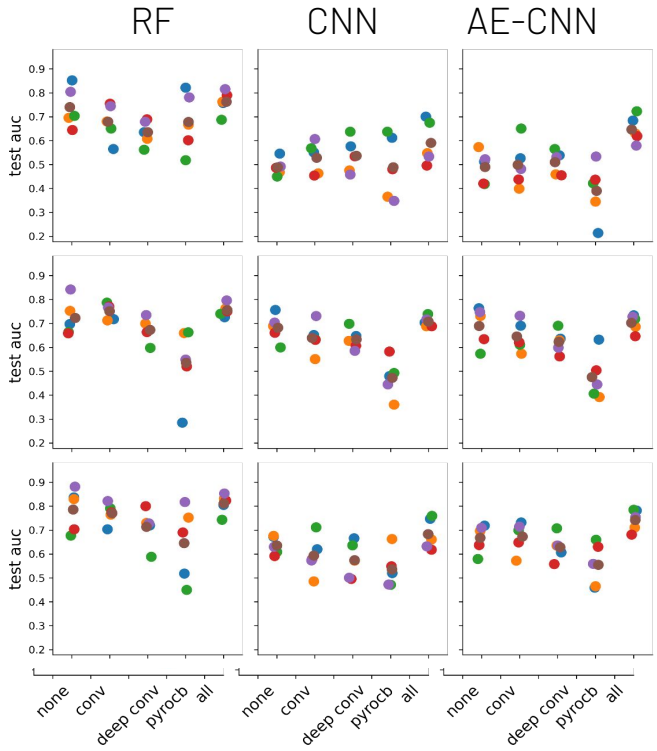
Average test AUC across 5 folds



Pyrocast | Forecasting Model

Forecasting

Test AUC by initial state and fold



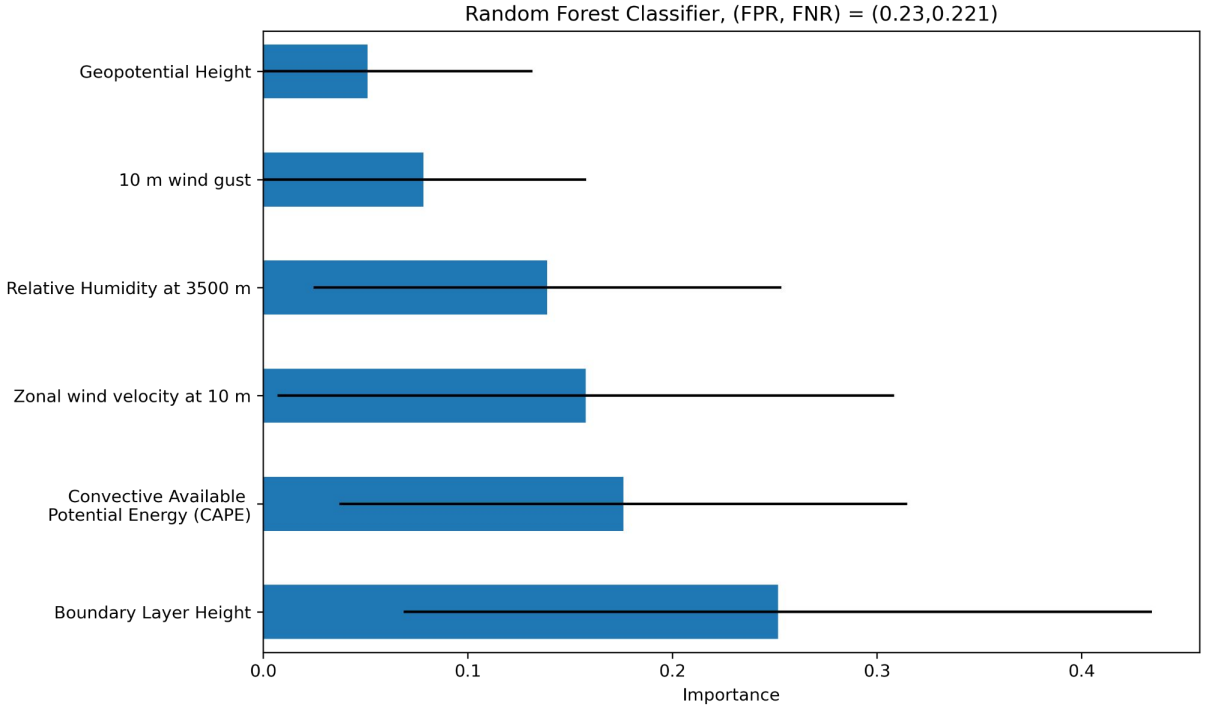
geostationary

meteorological

geostationary & meteorological

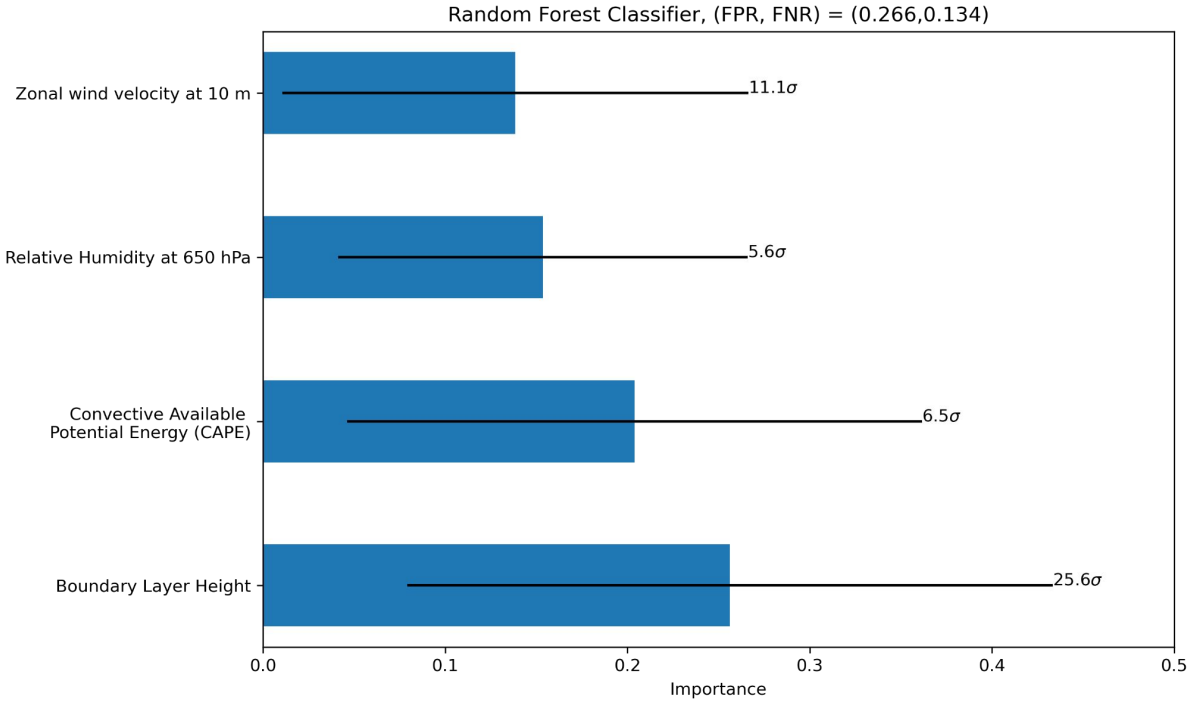
Pyrocast | Discovery Framework

Feature Importance with Random Forest Classifier



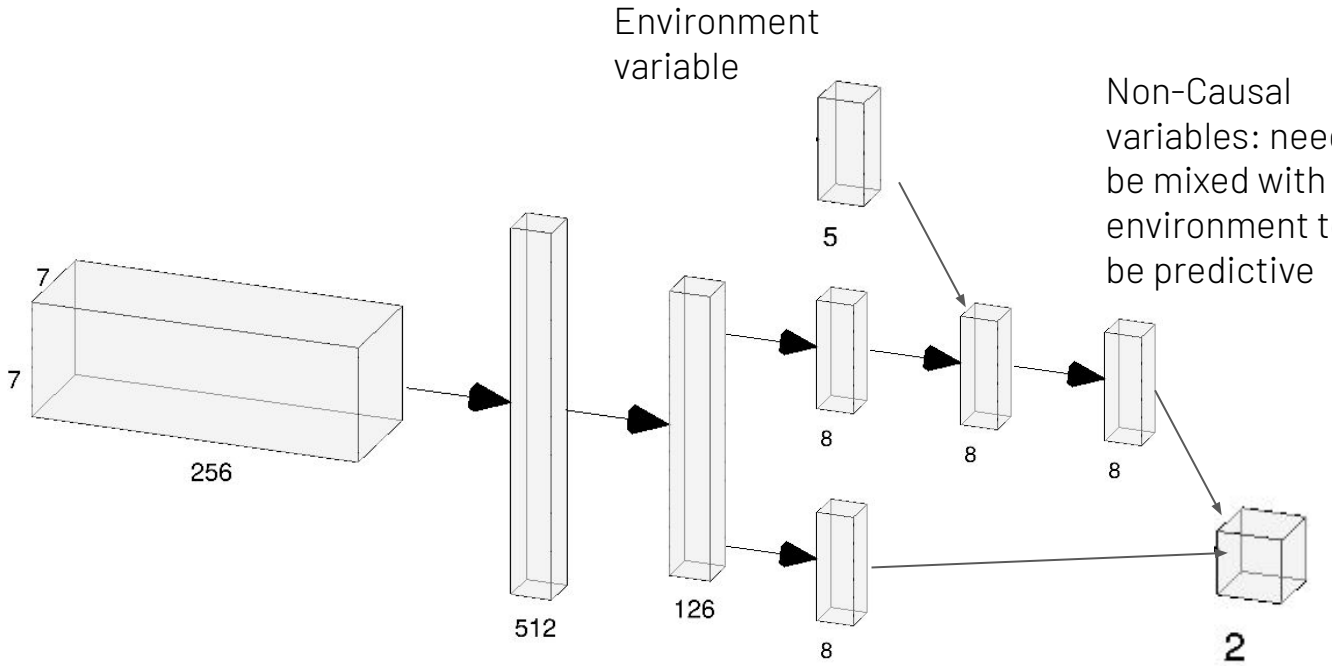
Pyrocast | Discovery Framework

Feature Importance with Random Forest Classifier



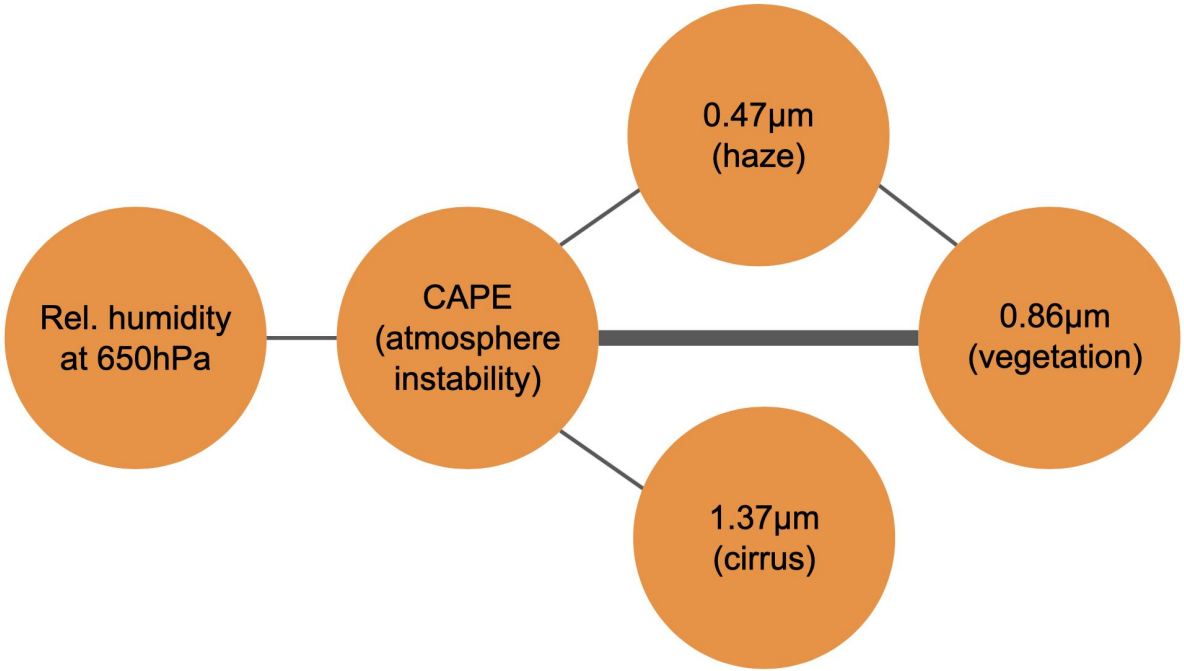
Pyrocast | Discovery Framework

Causal Invariance CNN Model



Pyrocast | Discovery Framework

Causal Invariance Results → Important causal interactions



Next Steps

- Detection algorithm
- Model pre-training
- Performance as a function of forecast time
- Saliency maps
- Other causal approaches

Conclusion

- First comprehensive PyroCb database
- First PyroCb forecasting system
- Better understanding of the properties and causes of PyroCb

FOR ALL HUMANKIND

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Appendix

TEMPLATE TO FOLLOW: POSTER TEMPLATE

TEMPLATE TO FOLLOW: TECH MEMO TEMPLATE

Week 8: Showcase Week - 8 - 12 August

In the final week of FDL, teams work on a polished TED- talk style live presentation (8 mins) and give their detailed technical presentation to key stakeholders.

In this last week, the teams have three key deliverables:

1. **The Technical Showcase.** This is a closed meeting to challenge stakeholders and experts.