Sustainable AI: inside the deep, alongside the green

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Intelligent Transportation Systems

Renewable Energy Sources

Precision Agriculture

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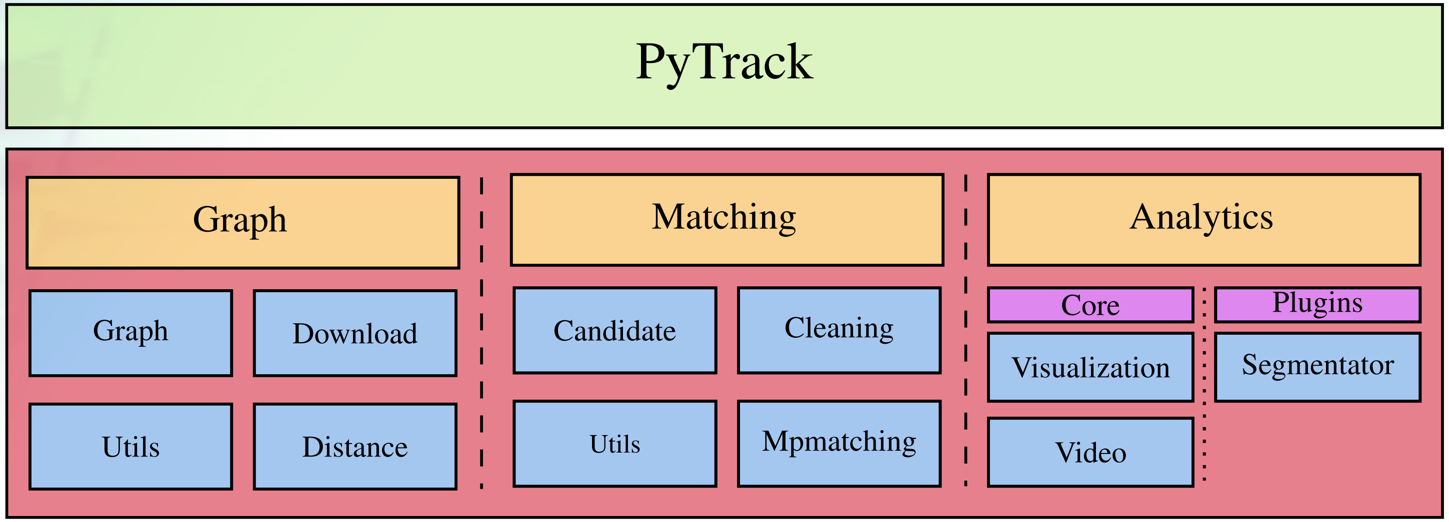
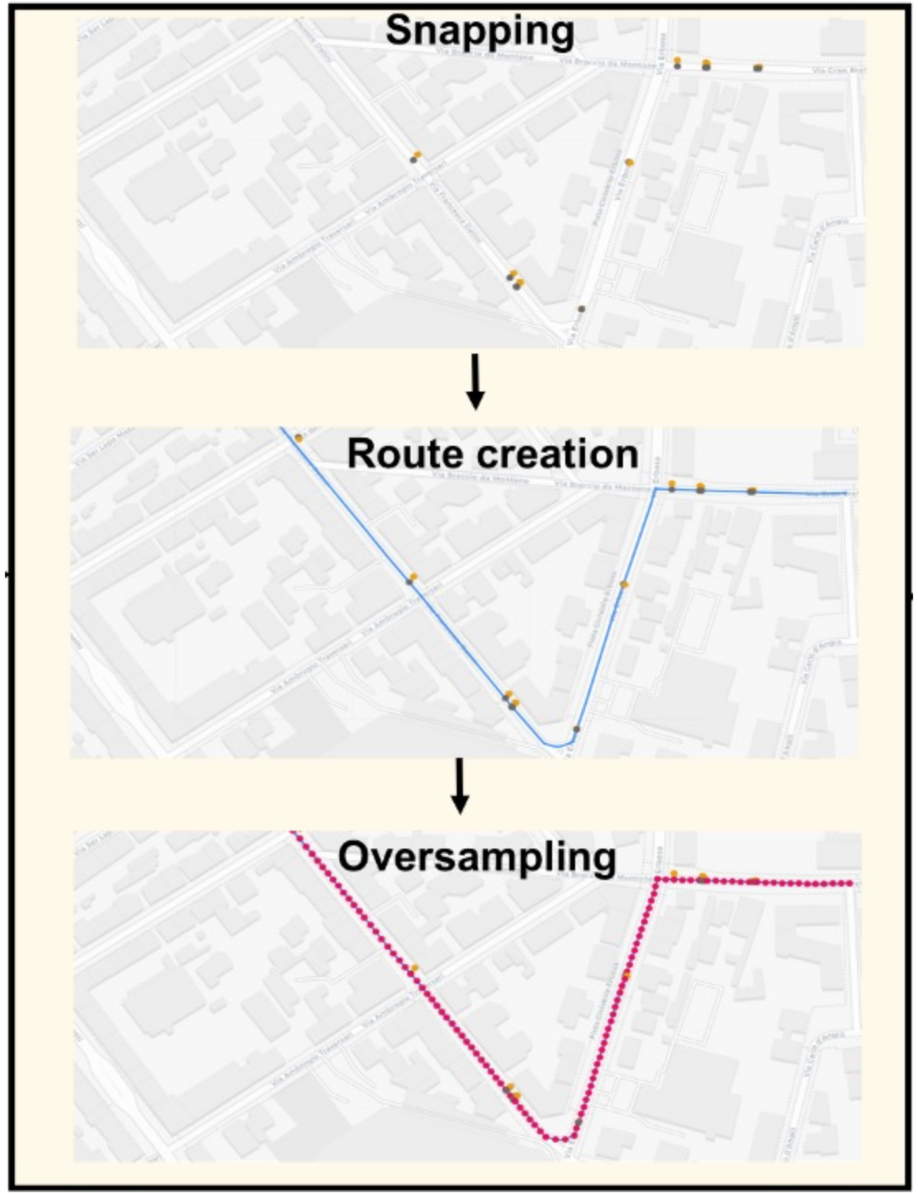
PyTrack: a Map-Matching-based Python Toolbox for Vehicle Trajectory Reconstruction

Map-matching: *it is the process to align the GPS sampling data to the actual underlying driving routes network layer.*

Main Features:

- Generation of the street network graph using geospatial data from OpenStreetMap
- Map-matching
- Data cleaning
- Video reconstruction of the GPS route
- Visualisation and analysis capabilities





[1] Tortora, Matteo, et al. "PyTrack: A Map-Matching-Based Python Toolbox for Vehicle Trajectory Reconstruction." IEEE Access 10 (2022): 112713-112720.
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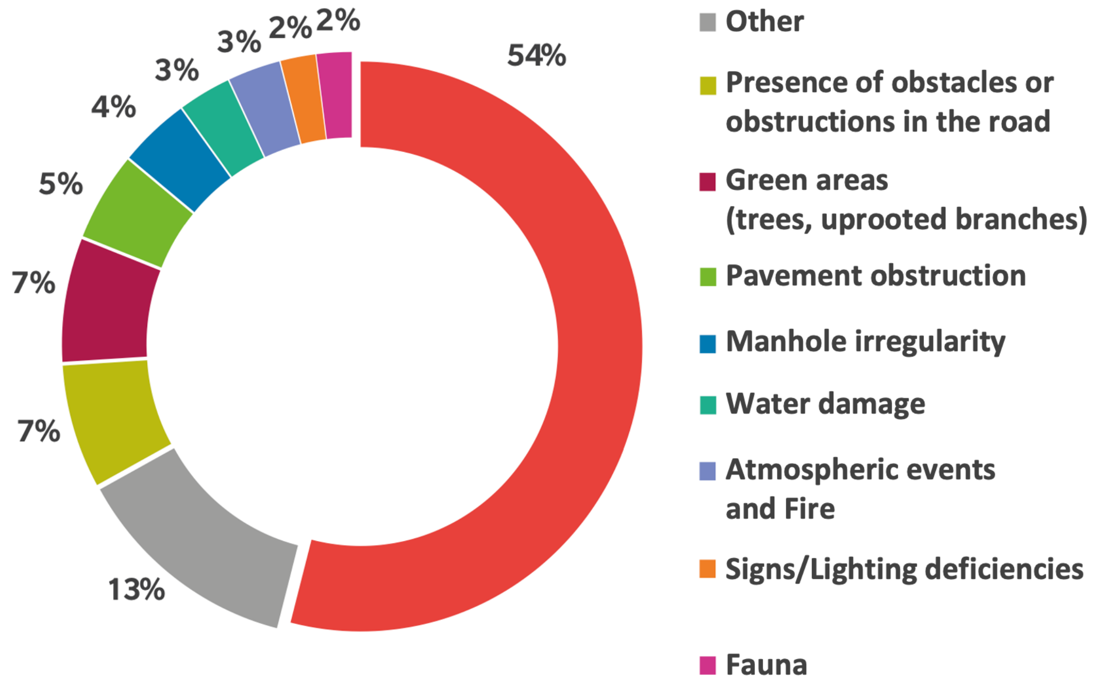
PyTrack: a Map-Matching-based Python Toolbox for Vehicle Trajectory Reconstruction

- A significant number of road accidents and vehicle damage occurs as a result of potholes/cracks;
- In most countries, local authorities allocate a significant amount of funds to repair them;
- However, due to their widespread nature, serious injuries or deaths still occur;
- The localisation of potholes/road cracks should thus be an
  to ensure safe driving.



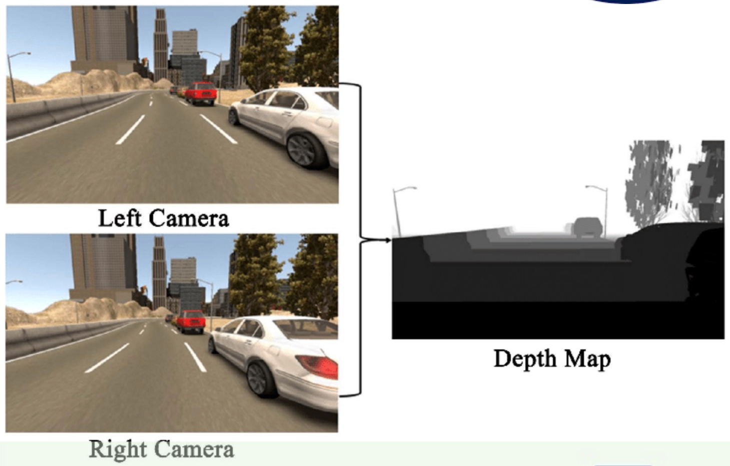
PyTrack: a Map-Matching-based Python Toolbox for Vehicle Trajectory Reconstruction

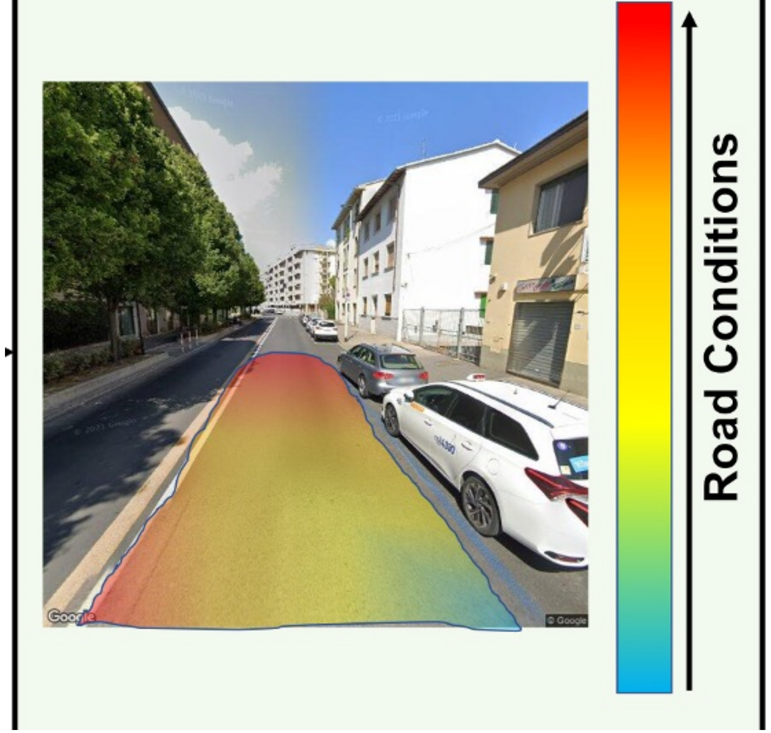
- The goal of this project is to develop **Computer Vision** methods for the segmentation and localisation of road damage;

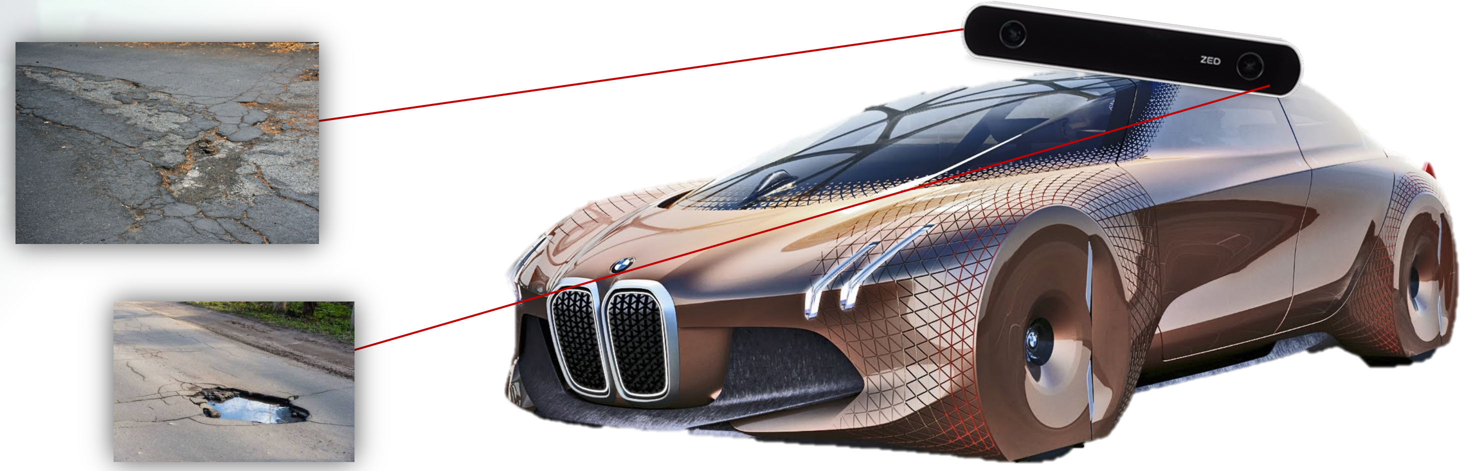
- Using a *multimodal* framework approach;

- Use of stereo cameras to acquire depth information; Use of RGB images and depth maps in combination to improve the predictive capability of the method;

- The method aims to improve road safety and vehicle drivability.







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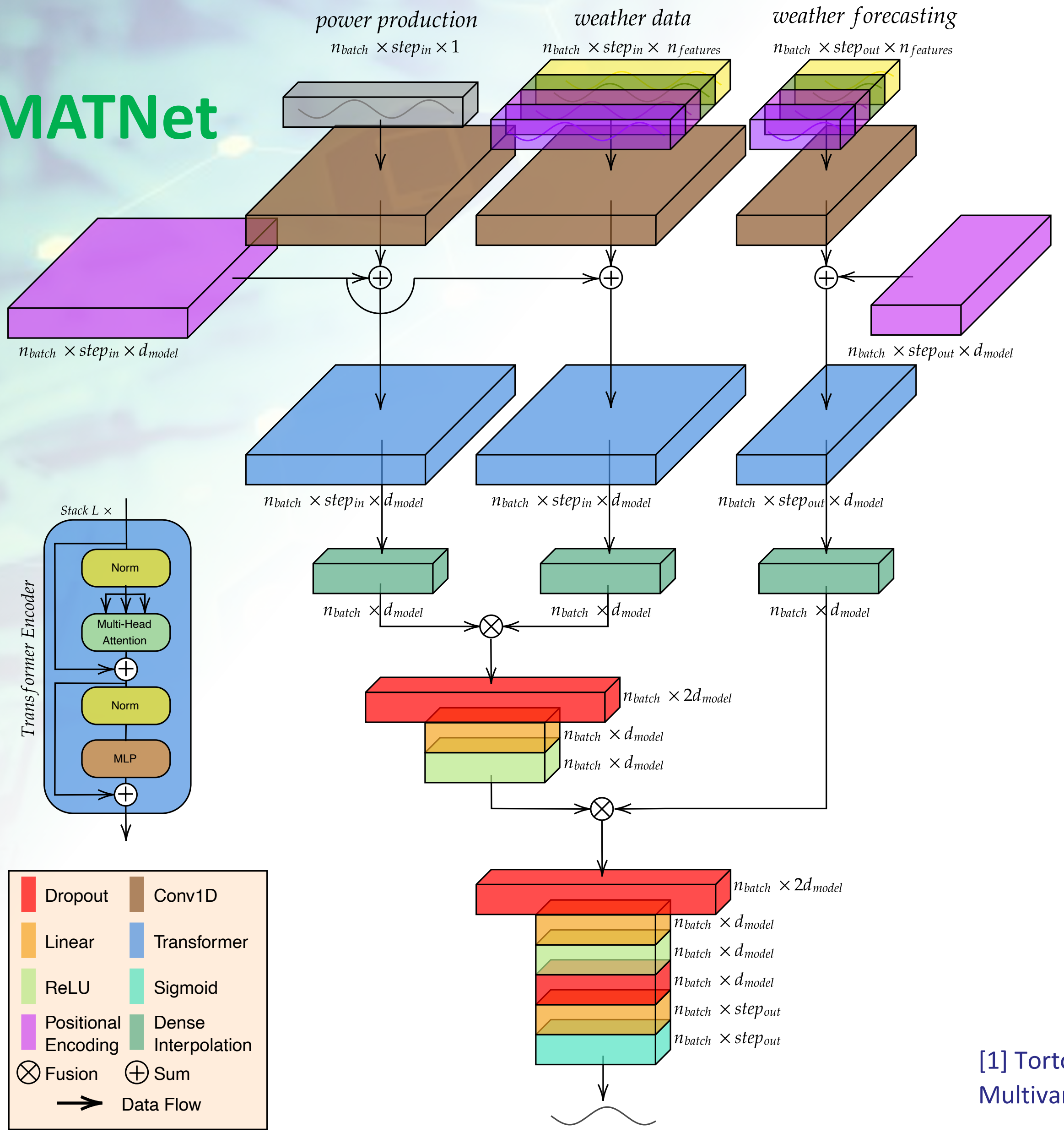
MATNet: a self-attention-based model for PV generation Forecasting

MATNet

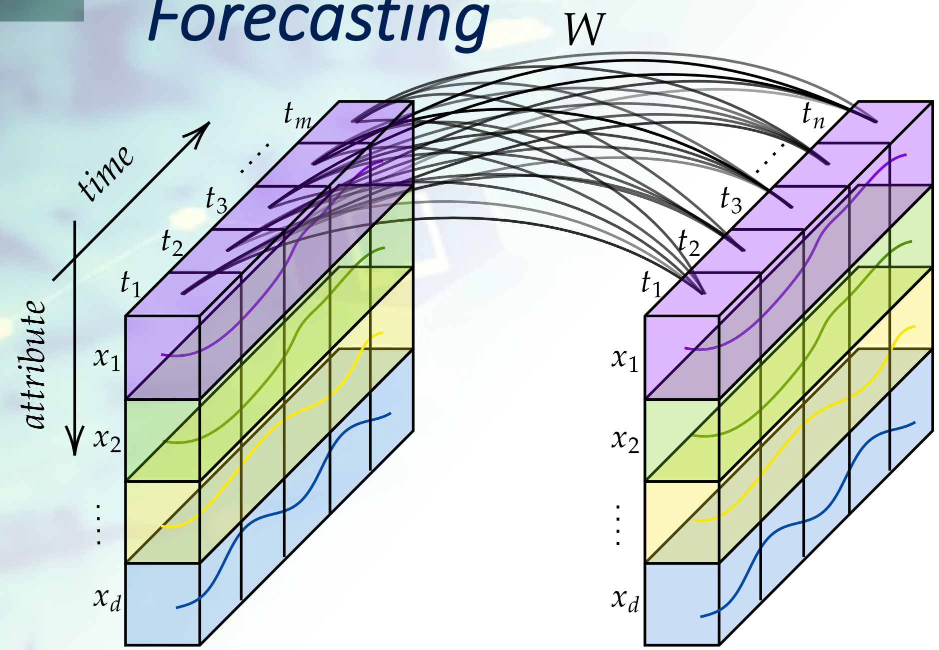


Rationale: to provide useful information to facilitate the integration of photovoltaic energy into the modern power grid. [Reference project: **ComER**]

- The attention mechanism is a vital part of the architecture enabling the model to focus on input data elements dynamically
- It is a hybrid approach combing both AI-based and physical-based methods
- We feed the model with historical photovoltaic data and historical and forecast weather data. The first was obtained from the Ausgrid dataset (electricity supplier in southern Australia), and the other two were acquired from OpenWeatherMap.
- We proposed also a dense interpolation module (figure on the left) to simplify the high-dimensional representation returned by the attention-based module.

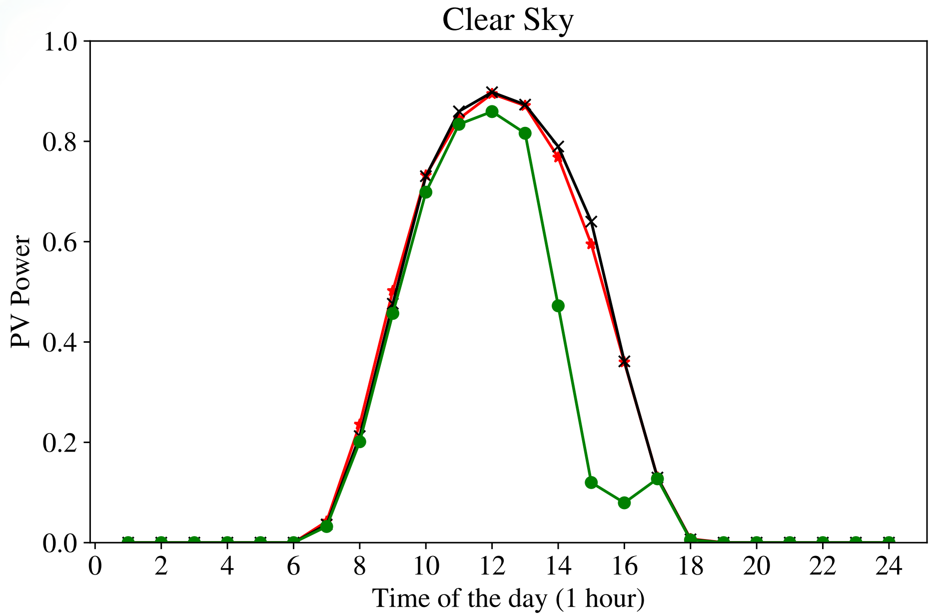
[1] Tortora, M., et al. »MATNet: Multi-Level Fusion and Self-Attention Transformer-Based Model for Multivariate Multi-Step Day-Ahead PV Generation Forecasting», submitted to Energy and AI (2023).

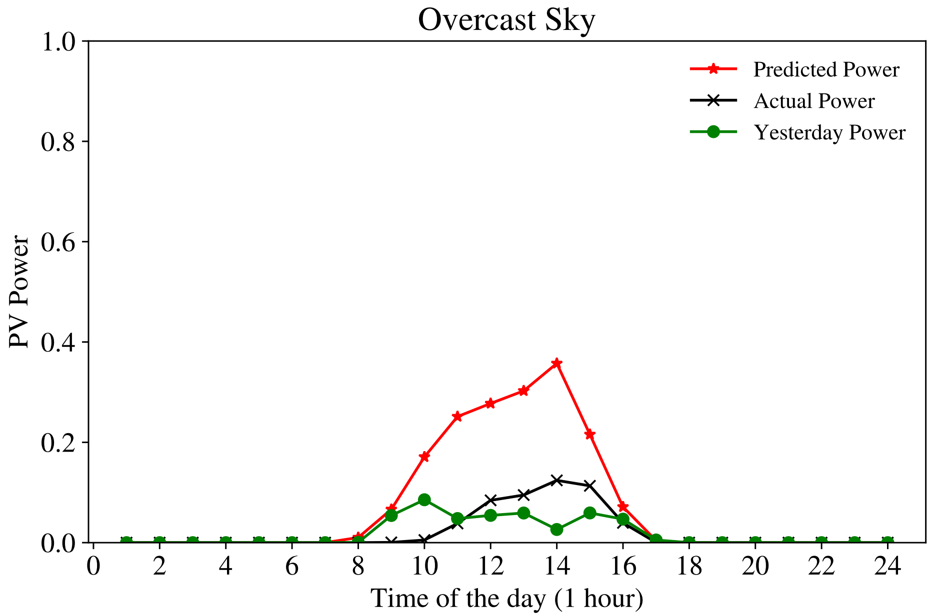
MATNet: a self-attention-based model for PV generation Forecasting



Rationale: to provide useful information to facilitate the integration of photovoltaic energy into the modern power grid. [Reference project: **ComER**]

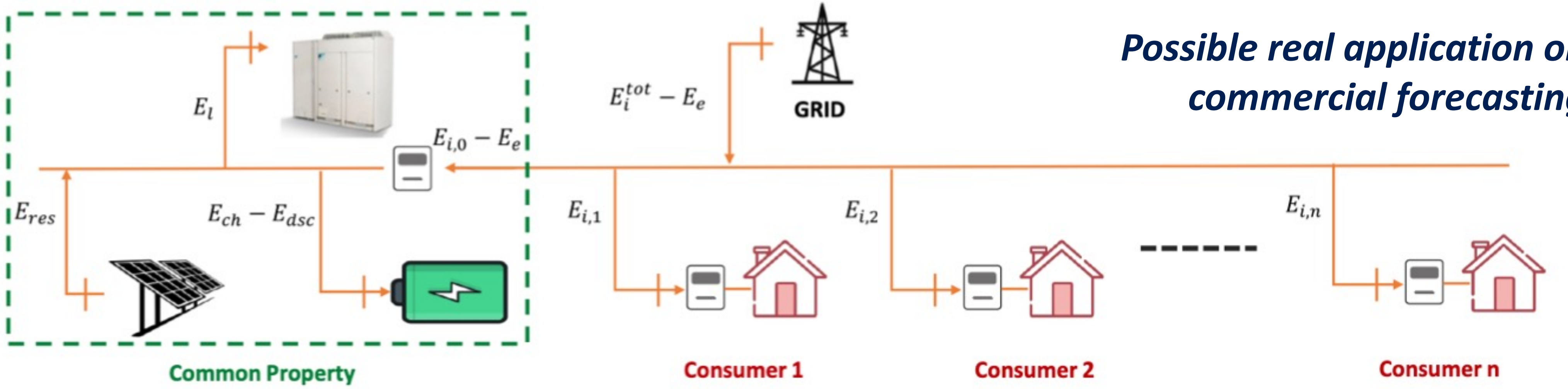
Architecture	MSE	RMSE	MAE	WMAPE	MASE
LsSVR [11]	-	-	4.95*	-	-
Bayesian BiLSTM [12]	-	0.0985	0.0679	-	-
Improved-Bayesian BiLSTM [13]	-	0.0854	0.0370	-	-
LSTM-based MATNet	0.0077	0.0723	0.0390	0.3007	0.7039
GRU-based MATNet	0.0070	0.0720	0.0392	0.2909	0.6934
BiLSTM-based MATNet	0.0085	0.0793	0.0432	0.3159	0.7494
BiGRU-based MATNet	0.0072	0.0724	0.0391	0.2824	0.6729
MATNet_wDIL[22]†	0.0851	0.2899	0.1589	1.206	2.9242
MATNet	**0.0062**	**0.0673**	**0.0366**	**0.2608**	**0.6265**

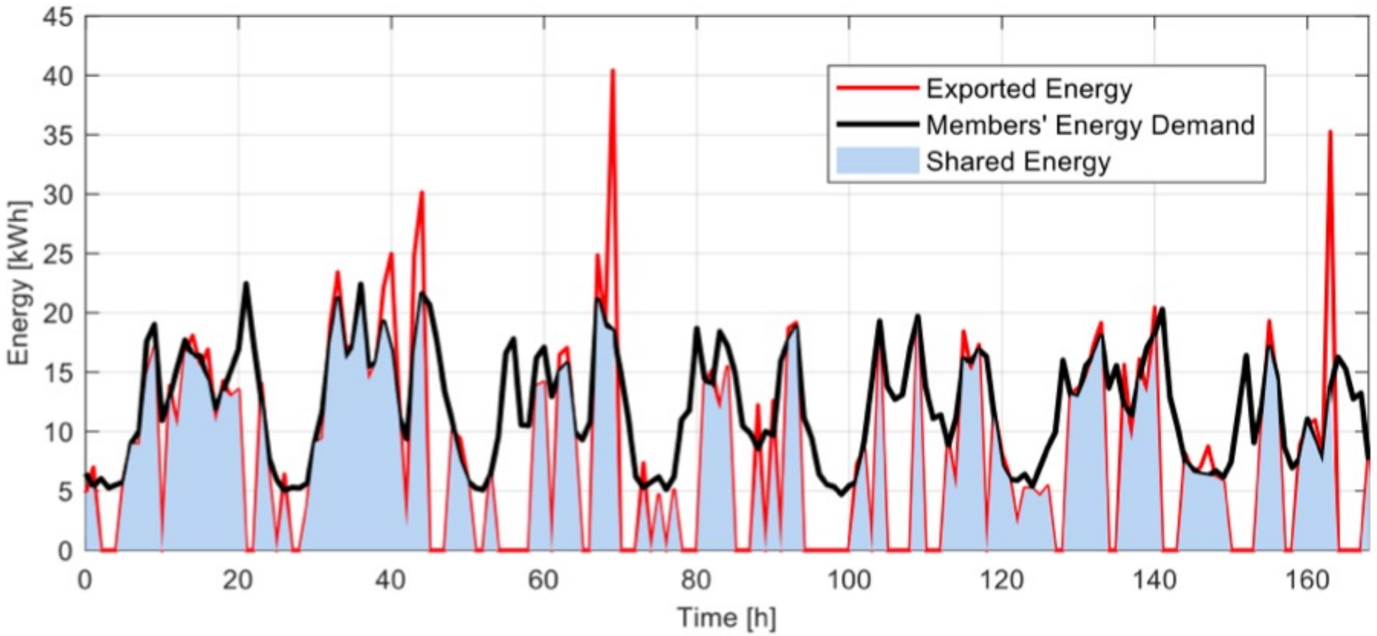




MATNet: a self-attention-based model for PV generation Forecasting

Possible real application on commercial forecasting





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Low Orchard Productivity Assessment exploiting Artificial Intelligence (AI)

- Mapping of the Kiwifruit Vine Decline Syndrome (KVDS), known as **Moria**, phenomenon on G3
- Using *satellite* image data

KVDS is a **complex phenomenon** generated by several factors **working in synergy** with each other.

Irrigation

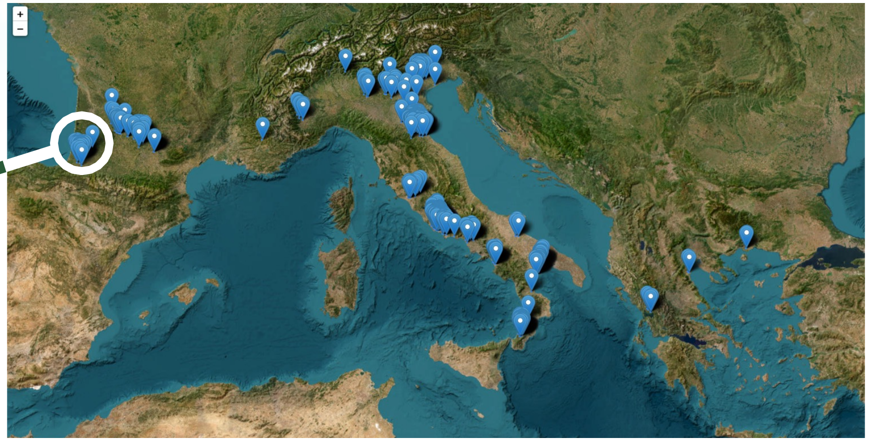
Temperature

Fertilization

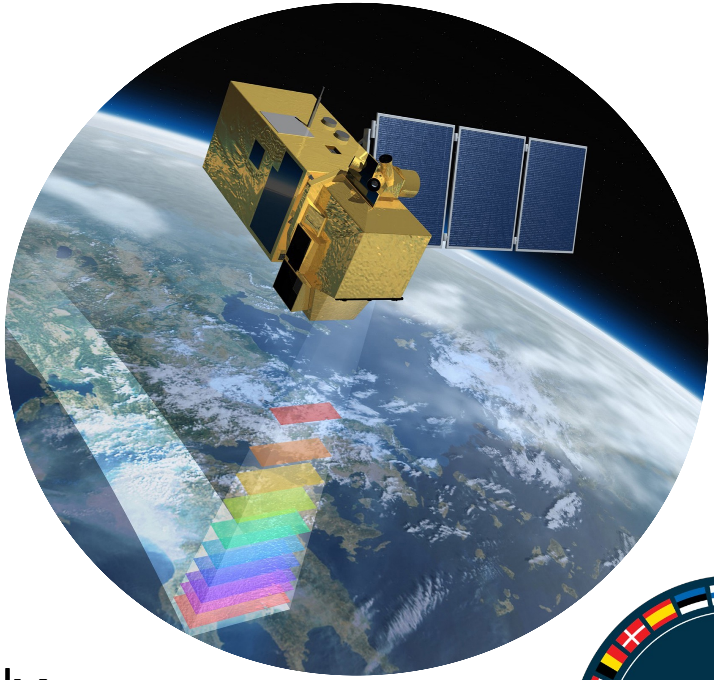
Weather

The KVDS Dilemma

4501 Maturity Areas (MA) provided by Zespri corresponding to
1538 KPINs (Zespri's partner farms for G3 project)

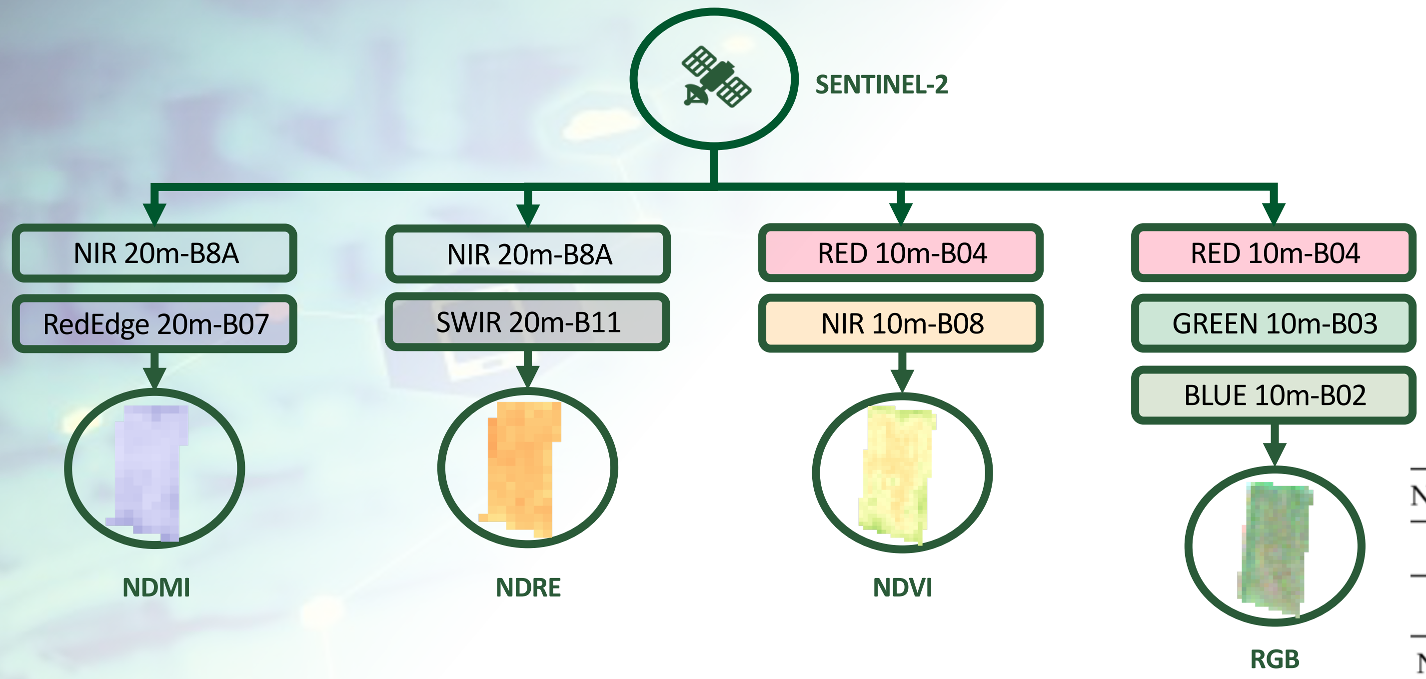


SENTINEL-2

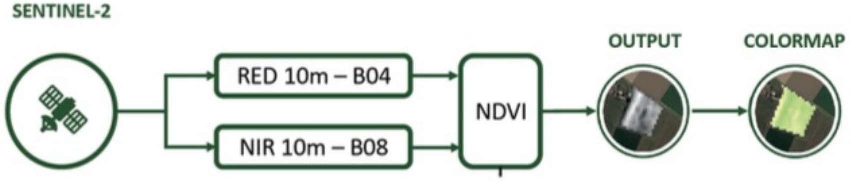


Constellation of **two polar-orbiting satellites** placed in the same sun-synchronous orbit, phased at 180° to each other

The KVDS Dilemma



Merging of image data

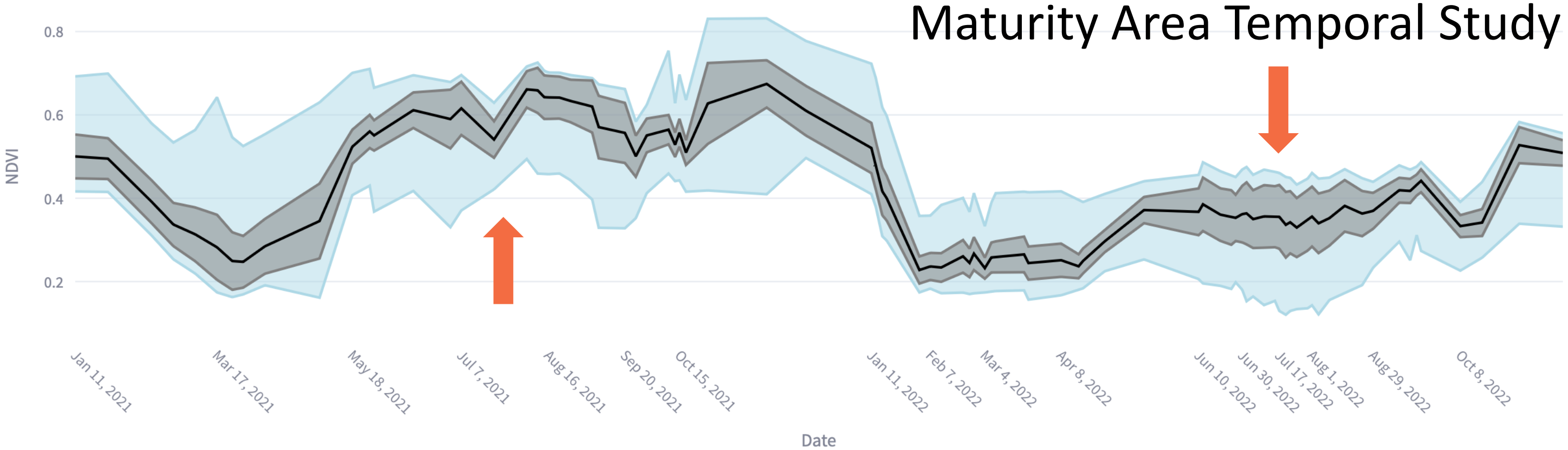


$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}} = \frac{\text{B08} - \text{B04}}{\text{B08} + \text{B04}}$$

Index	Equation Using Landsat 8 OLI [35]
Normalized Difference Vegetation Index (NDVI)	$\frac{NIR - Red}{NIR + Red}$
Enhanced Vegetation Index (EVI)	$2.5 \times \frac{NIR - Red}{NIR + 6 \times Red - 7.5 \times Blue + 1}$
Normalized Difference Water Index (NDWI)	$\frac{(SWIR_1 + Red) + (NIR + Blue)}{(SWIR_1 + Red) - (NIR + Blue)}$
Normalized Difference Moisture Index (NDMI)	$\frac{NIR - SWIR_1}{NIR + SWIR_1}$
Bare Soil Index (BSI)	$\frac{Green + NIR}{Green - NIR}$

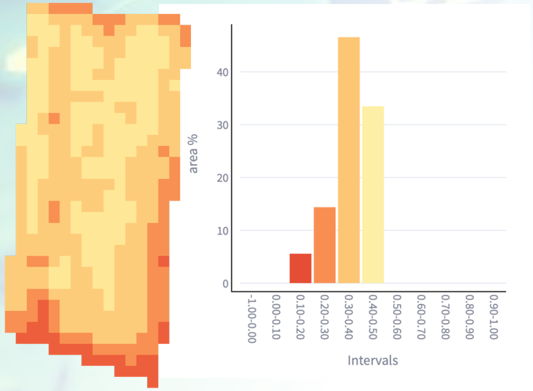
- Higher stress conditions during Q2/Q3 2022 with respect to Q2/Q3 2021;
  - Q2/Q3 2021 -> mean NDVI ~0.6;
  - Q2/Q3 2022 -> mean NDVI ~0.4;
- General condition of stress regardless the presence of KVDS;

Maturity Area Temporal Study

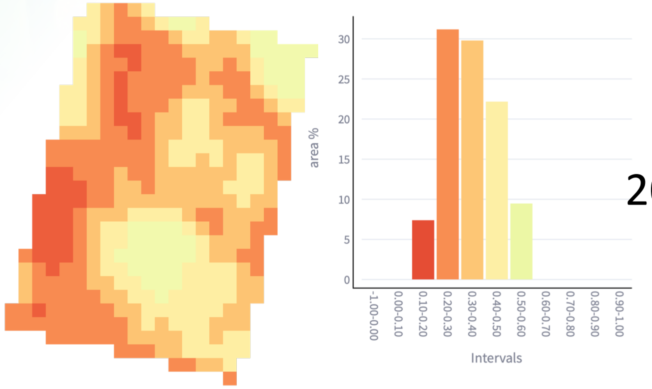


The KVDS Dilemma

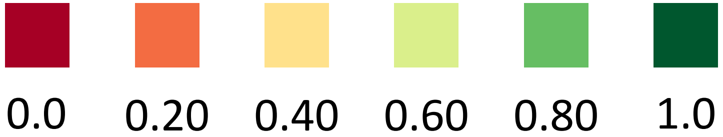
From connectivity analysis we see that both the maturity area has an interval of localized stress. But is it KVDS or not?



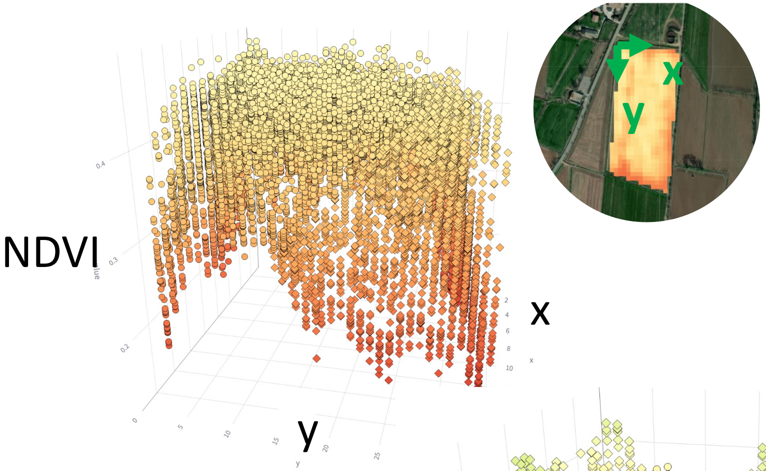
2022-07-15, NO KVDS

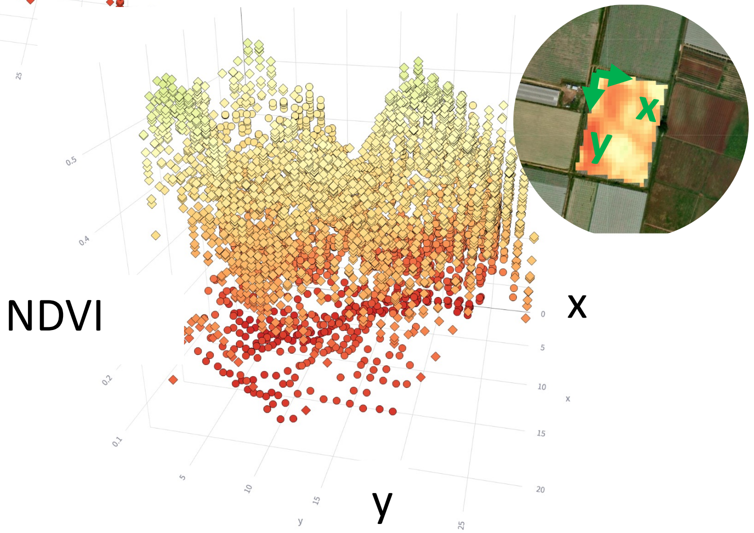


2022-07-14, KVDS



2022-05-01 to 2022-09-30, NO KVDS

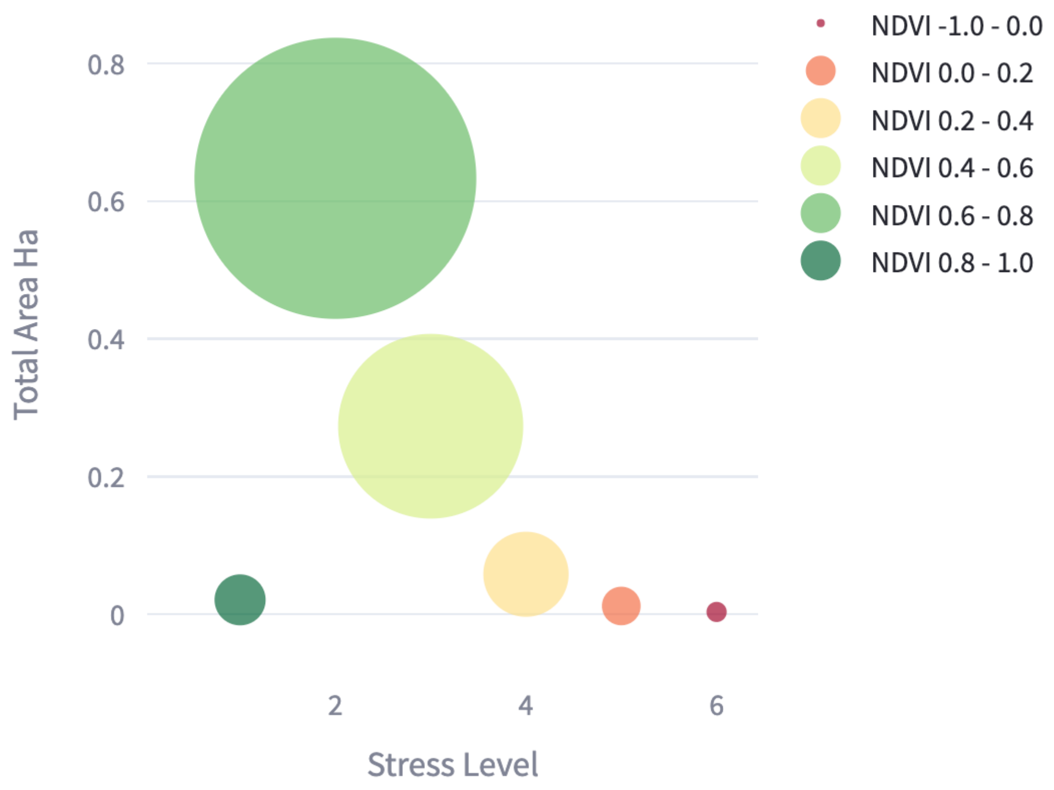




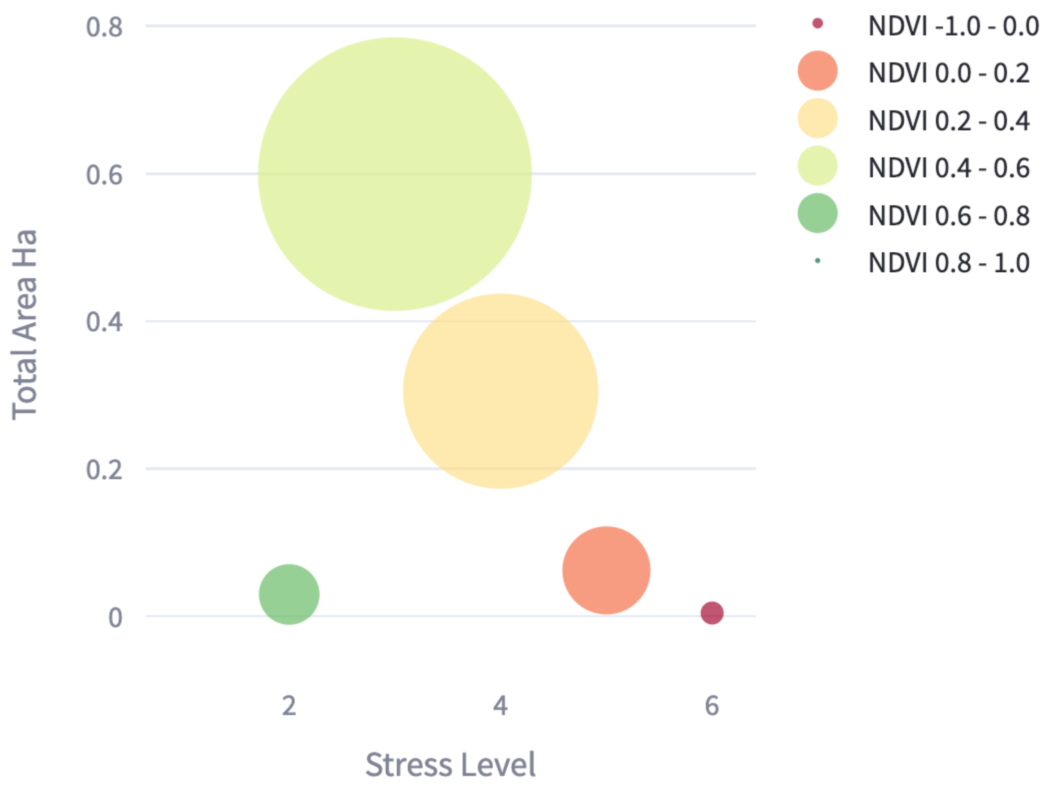
2022-05-01 to 2022-09-30, KVDS

The KVDS Dilemma

Region: Lazio



2021-05-01 to 2021-09-30



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