

Germ of life : prédiction d'indicateurs de sécheresse en Méditerranée

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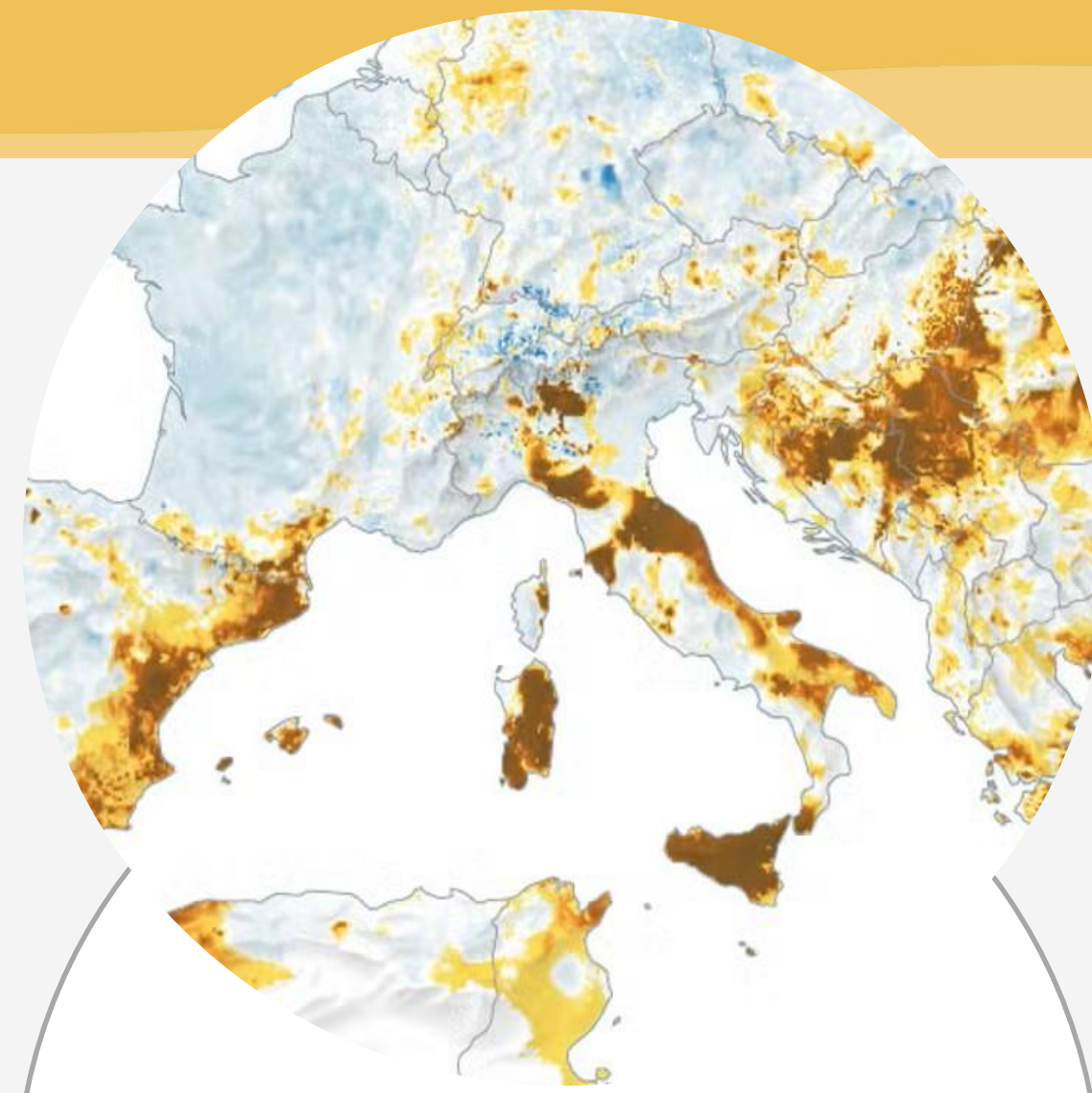


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3 pillars

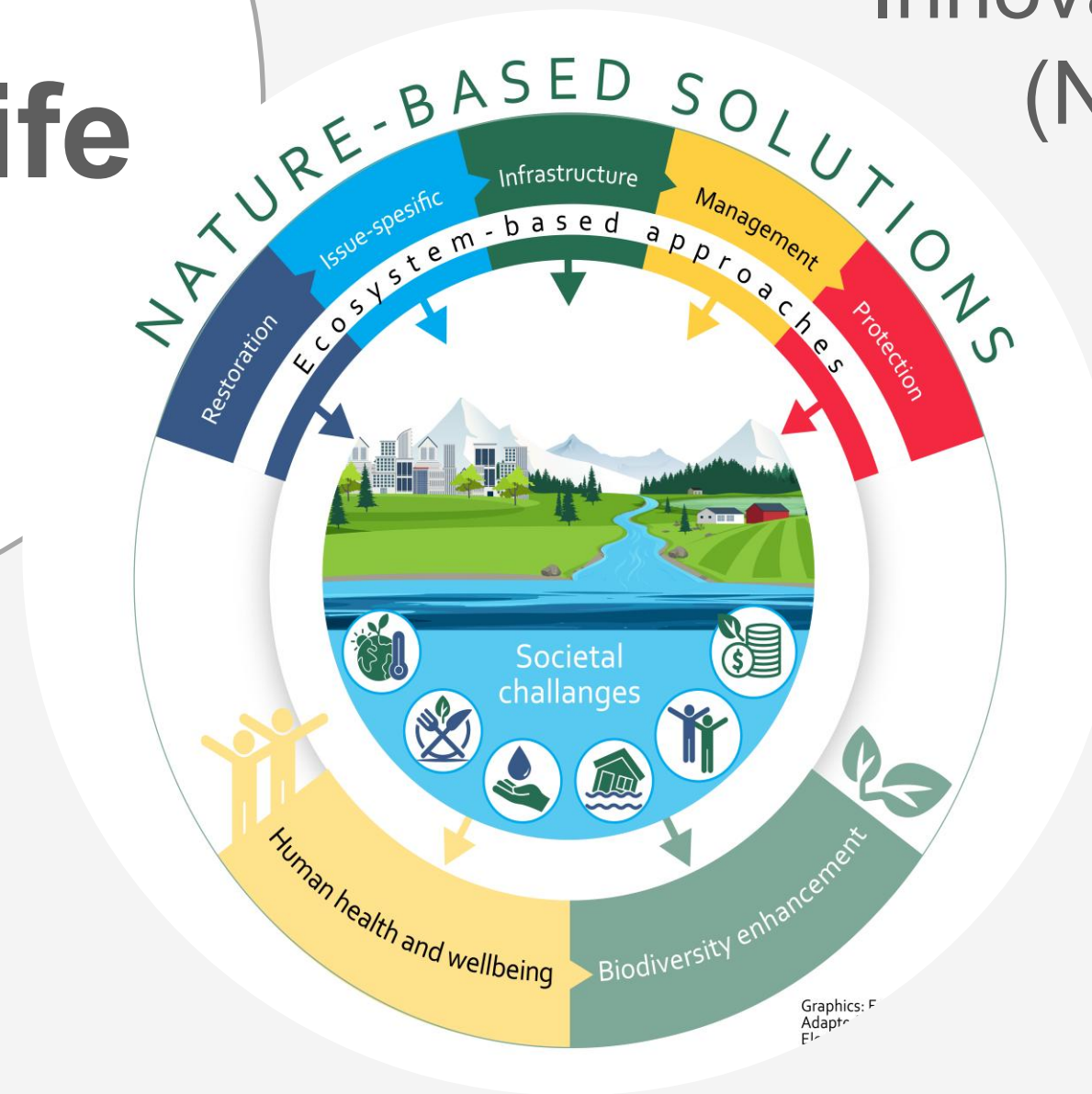
Drought Prediction Tool



Vulnerability Assessment Tool

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Innovation Procurement Platform
(Nature Based Solutions)



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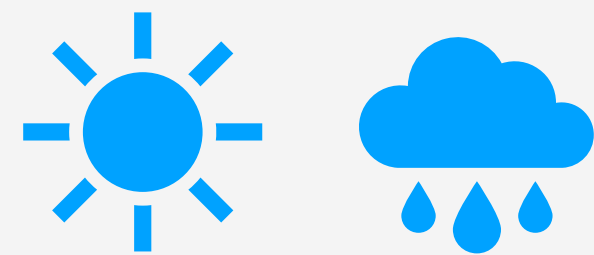


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What type of drought are we tackling exactly?

Selected drought indicators and new index



**Meteorological drought
(SPEI)**



**Stressed vegetation
(NDVI)**



**Crop water stress index
(CWSI)**



**DHI = Drought Hazard Index
(SPEI then NDVI & CWSI – GoL defined)**

2. Climatic Water Balance

Begueria et al 2014

The next step to compute SPEI is to compute the water balance:

$$D_i = P_i - PET_i$$

3. Accumulation at Time Scale k

To compute SPEI at a specific time scale kk (e.g., 1, 3, 6, or 12 months), the water balance series DD is aggregated over kk consecutive time steps. For each time step tt , the accumulated water balance $Dk(t)$ is given by:

$$D_k(t) = \sum_{j=0}^{k-1} D(t-j)$$

This results in a time series of kk -month accumulated water balance values, which forms the basis for the subsequent statistical analysis.

4. Log-Logistic Distribution CDF

A probability distribution is fitted to the accumulated water balance series Dk for each calendar month (to account for seasonal variability). The standard SPEI methodology employs a three-parameter log-logistic distribution with parameters:

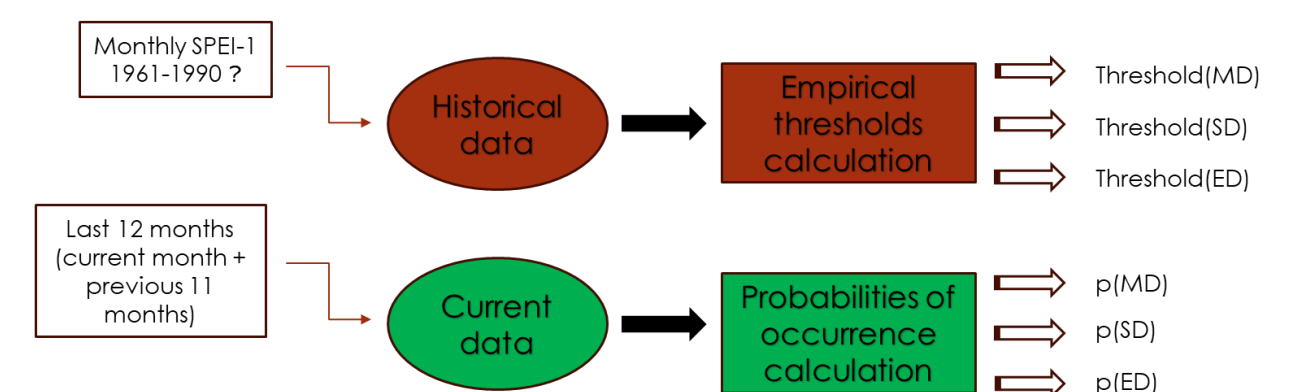
- Scale parameter α

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

$$CWSI = 1 - \frac{\lambda ET}{R - G} \quad CWSI = 1 - \frac{E}{E_p}$$

$$DHI = (NN_w \cdot NN_r) + (MD_w \cdot MD_r) + (SD_w \cdot SD_r) + (ED_w \cdot ED_r)$$

$$= 1 + (2 \cdot MD_r) + (3 \cdot SD_r) + (4 \cdot ED_r)$$



Condition	Rating value
$p \leq 0.25 \cdot \text{threshold}$	1
$0.25 \cdot \text{threshold} < p \leq 0.50 \cdot \text{threshold}$	2
$0.50 \cdot \text{threshold} < p \leq 0.75 \cdot \text{threshold}$	3
$p > 0.75 \cdot \text{threshold}$	4

→ DHI of current month



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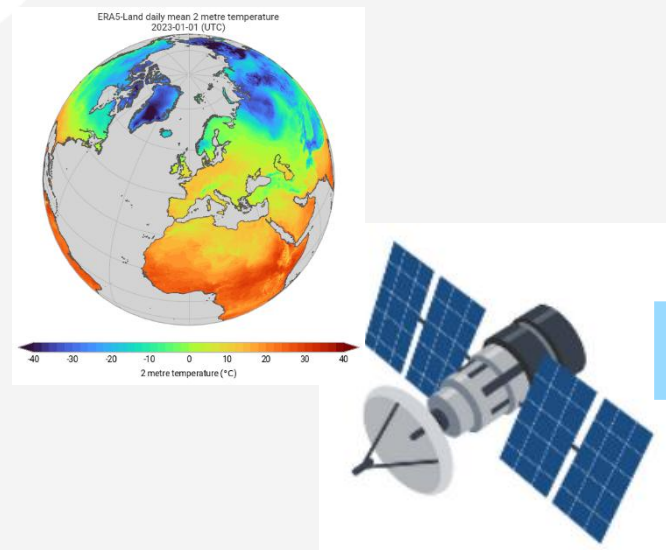
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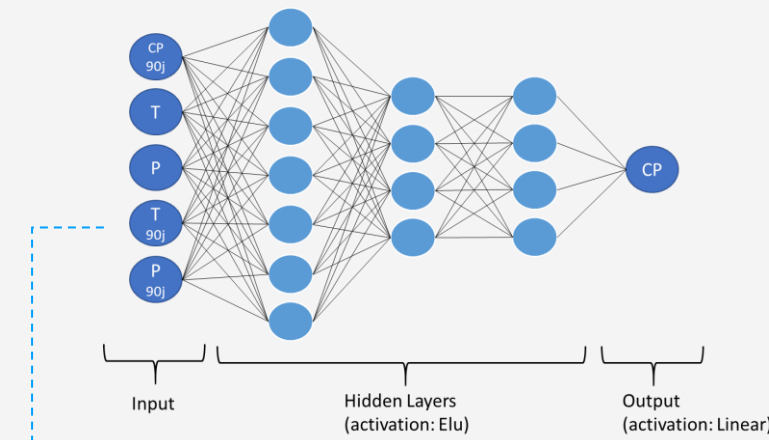
Drought characterisation and Prediction Tool

Assessing past, current and future drought conditions

Historical
time series



ERA5 land reanalysis
data & Sentinel 2



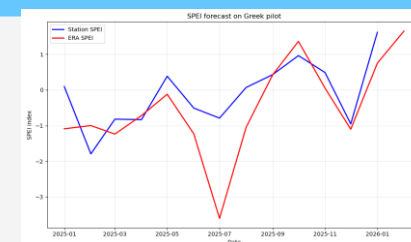
Automated algorithms (SPEI)
& AI models training (NDVI)

Real time
conditions

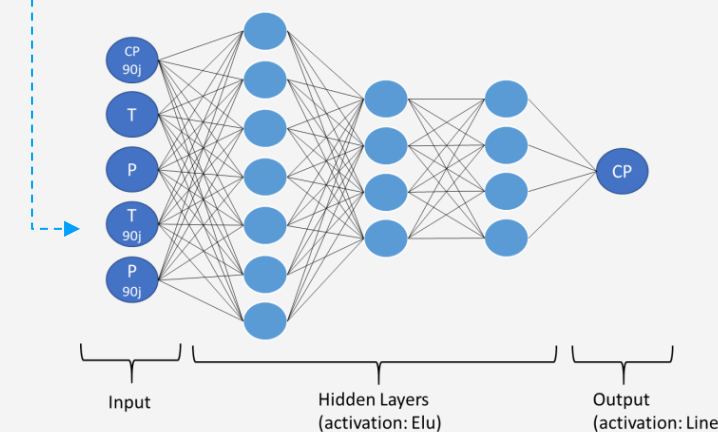


Ground stations

Computed SPEI

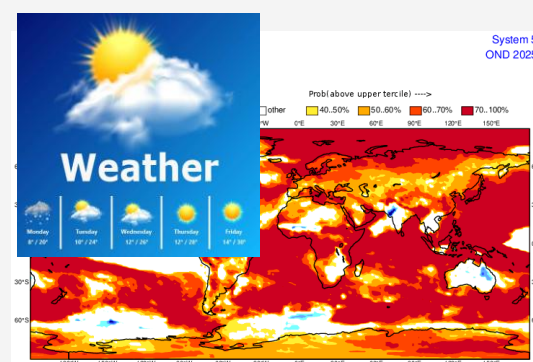


Measured NDVI



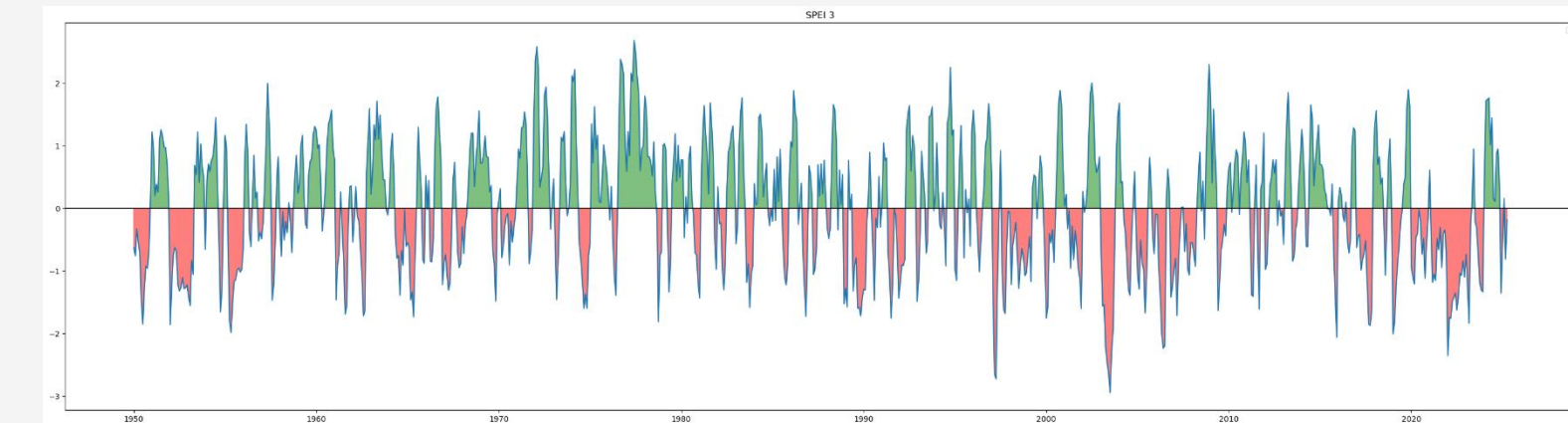
Automated algorithms (SPEI)
& AI models inference (NDVI)

Forecast
mode



ECMWF meteorological forecasted data

Past drought conditions



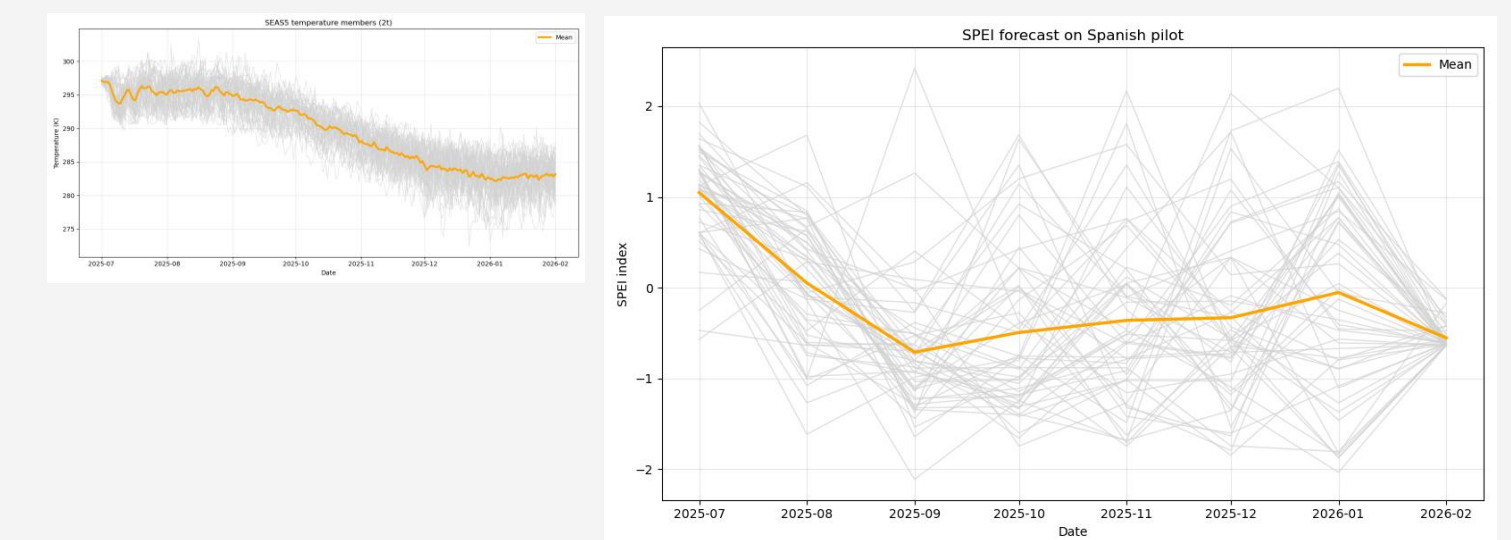
SPEI 1950- today for the 4 GoL sites, NDVI 1980- now

Current drought conditions

- Meteorological drought (SPEI)
- Vegetation stress (NDVI) and
- Hazard Index (DHI) + combined indicator



Future drought conditions

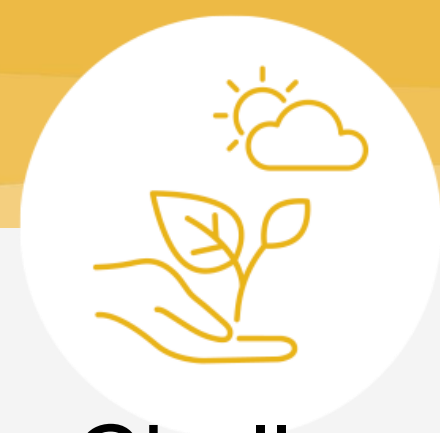


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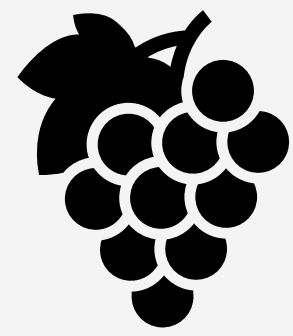


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NDVI modelling on different agro-ecosystems

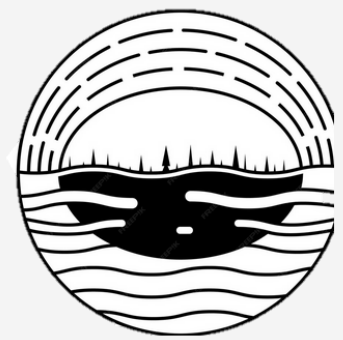
Challenges of behaviour (vegetation/soil/water and several types of stress)



Vineyards (Western Greece region)



Grassland (Pô River park, Italy)



Temporary ponds (Alentejo, Portugal)



Cereal fields (Andalusia, Spain)



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NDVI modelling on different agro-ecosystems

Smooth = Savitsky-Golay filter adapted
(Chen et al. 2018)

Polynomial regression versus ANN

Cross validation & separate test

Modified inputs based on signal analysis
and literature (feature engineering)

Selection & Relative importance of variables

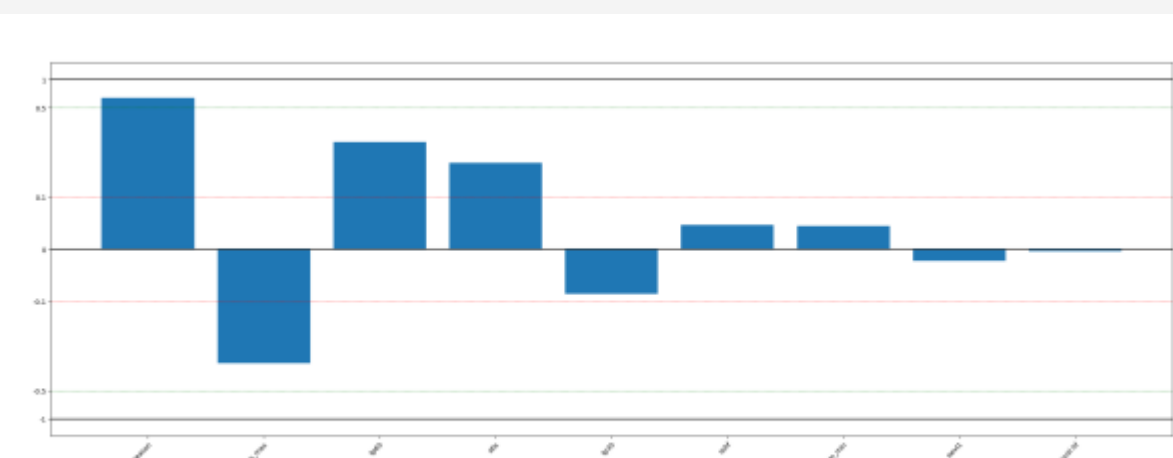
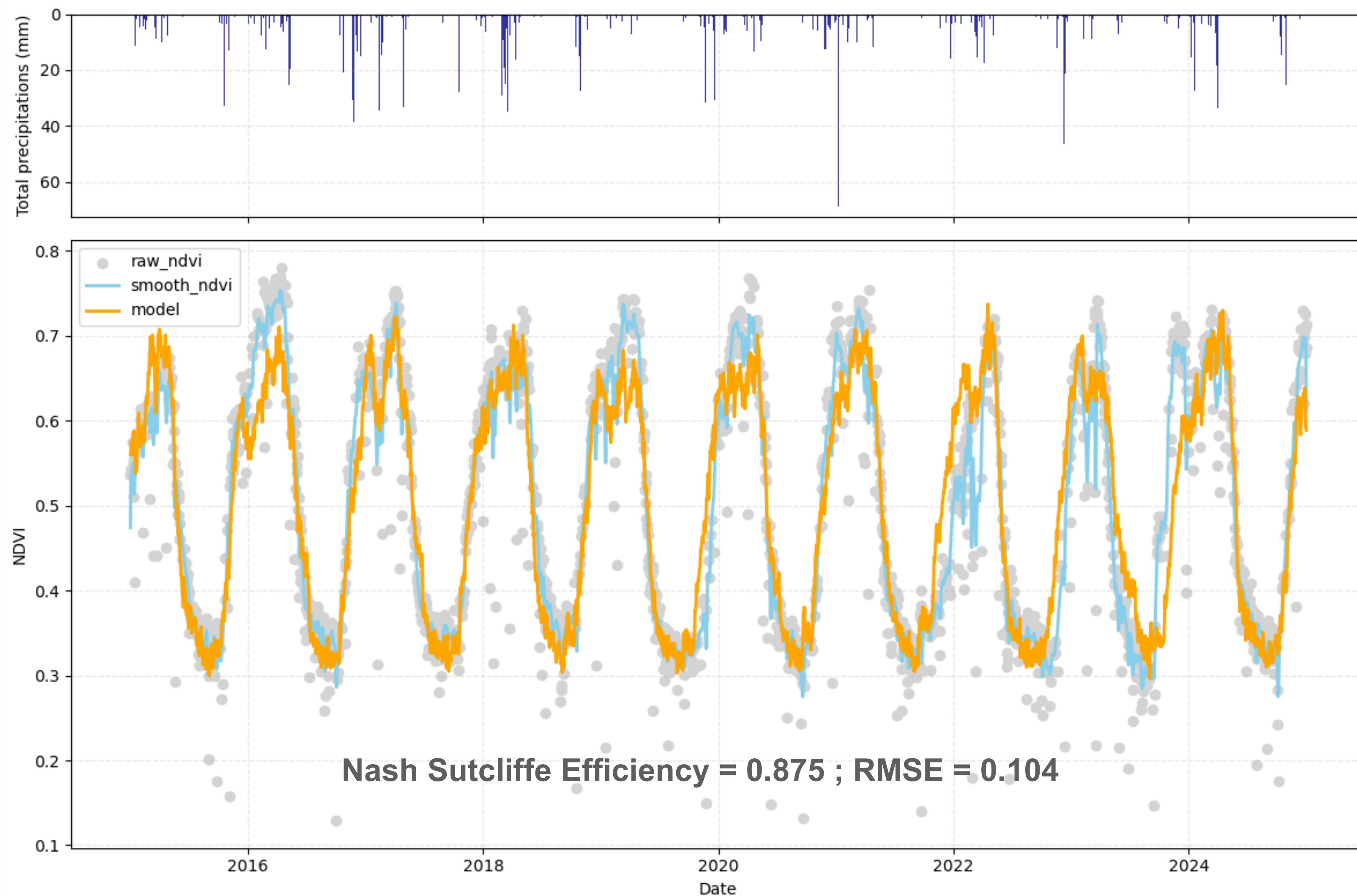


Figure 7: Contributing variables, Spanish pilot



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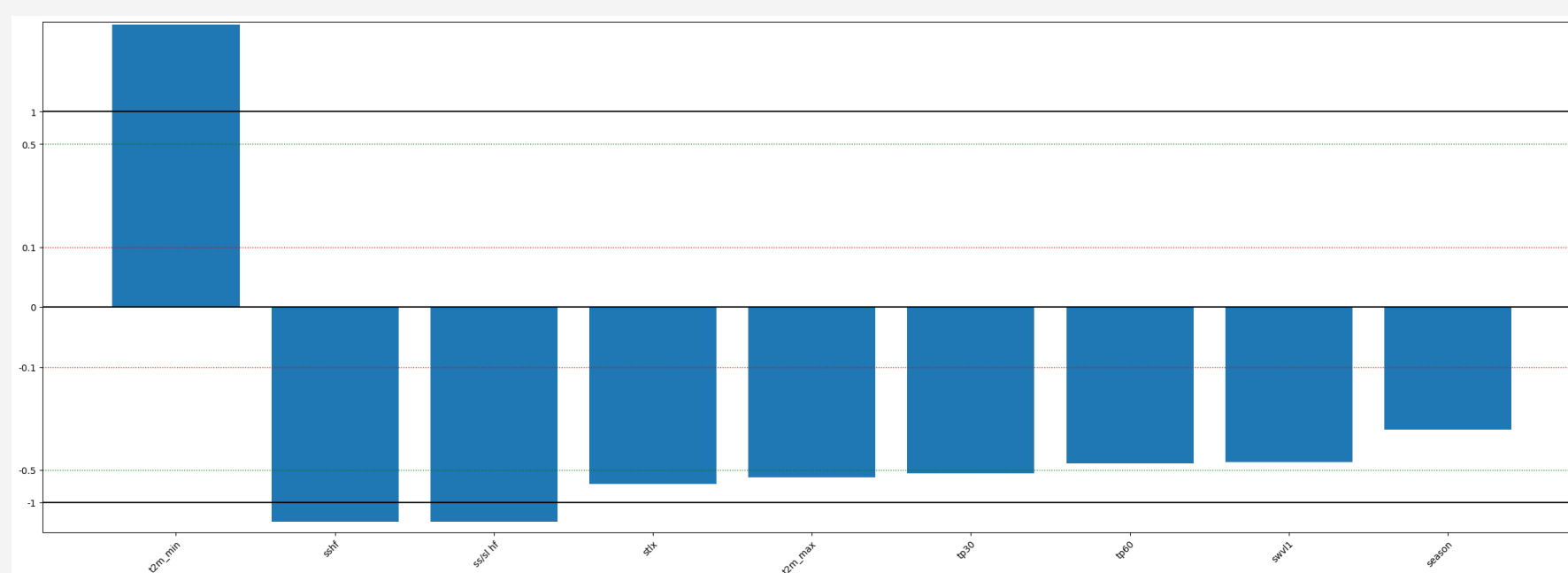


NDVI modelling on different agro-ecosystems

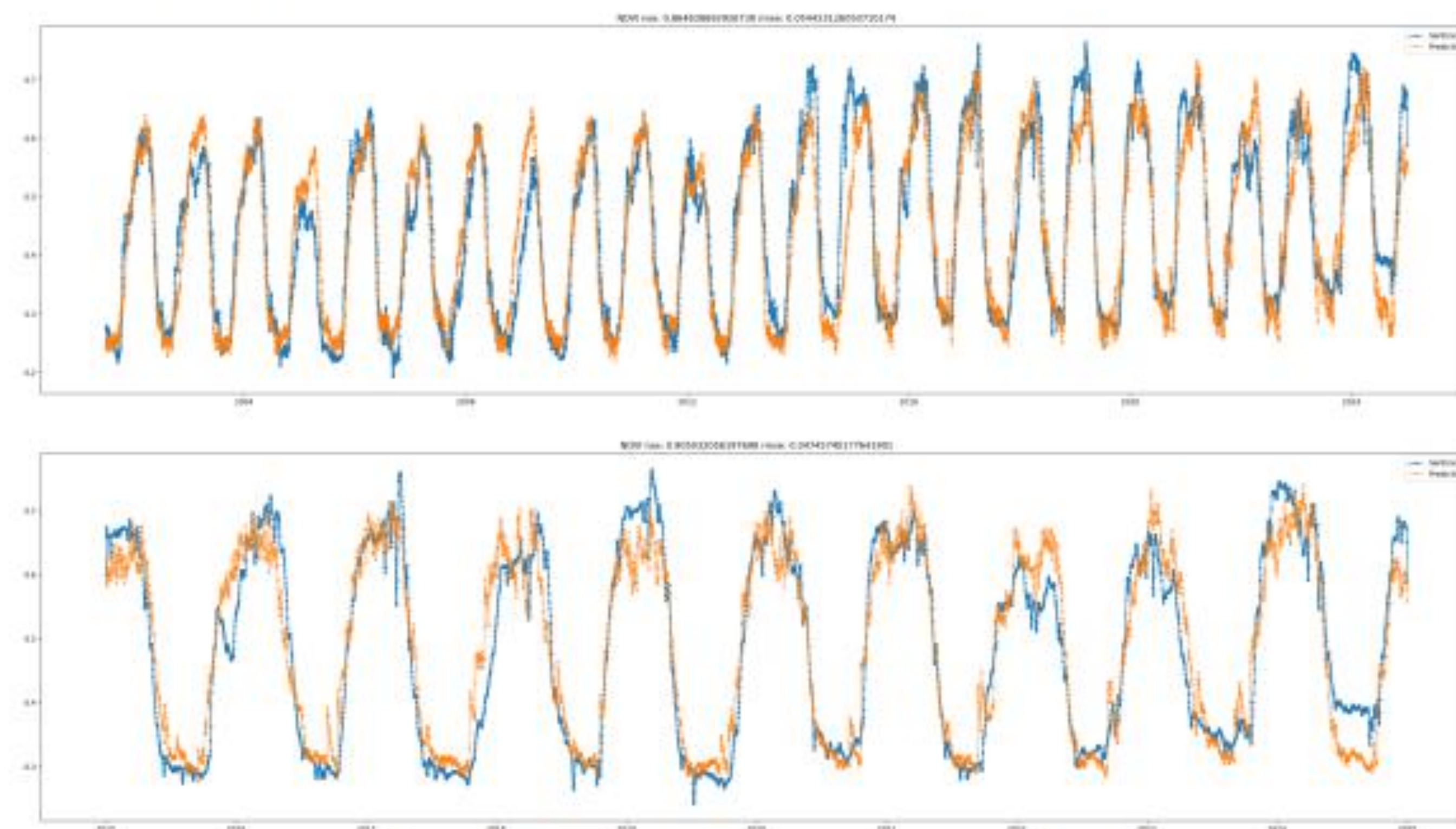
Portuguese Pilot

The structure defined on Spanish Pilot provided high performance.

Challenges of scale versus local behaviour (temporary ponds)



Portuguese pilot



Performance on 2015-2025: NSE = 0.905, RMSE= 0.047 Performance on period 2000-2025: NSE = 0.85, RMSE=0.054



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Drought Hazard Index

Four severity levels

Near Normal (NND),

Moderate Drought (MD),

Severe Drought (SD)

Extreme Drought (ED)

with fixed weights assigned to each class
($NND_w=1$, $MD_w=2$, $SD_w=3$ and $ED_w=4$).

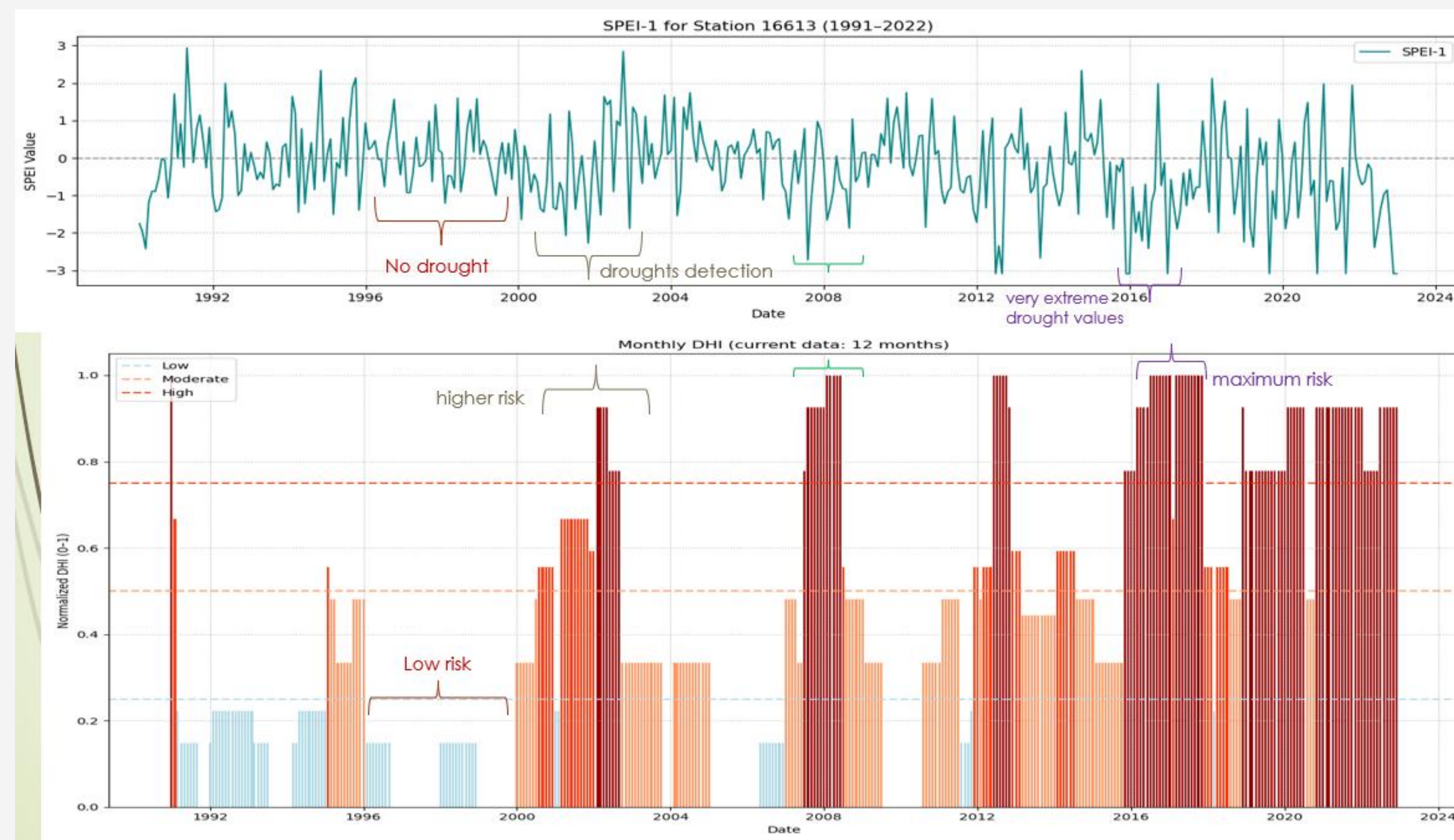
Classes are then according to their **occurrence frequency across spatial units** (NND_r , MD_r , SD_r and ED_r) and the overall DHI is computed as a weighted sum of severity ratings, normalized to a [0,1] range.

DHI computed from SPEI, NDVI anomaly

Ecosystem-specific weights for the Mediterranean region:

- 1.Forest: $SPEI=0.75$, $NDVI=0.25$ (SPEI dominates due to water needs of trees)
- 2.Shrubland: $SPEI=0.65$, $NDVI=0.35$ (balanced due to visible shrub stress)
- 3.Grassland: $SPEI=0.60$, $NDVI=0.40$ (NDVI reflects rapid grass response)
- 4.Arid: $SPEI=0.55$, $NDVI=0.45$ (NDVI critical in sparse vegetation)
- 5.Wetland: $SPEI=0.80$, $NDVI=0.20$ (SPEI tracks water supply)

$$DHI = (NND_w * NND_r) + (MD_w * MD_r) + (SD_w * SD_r) + (ED_w * ED_r)$$



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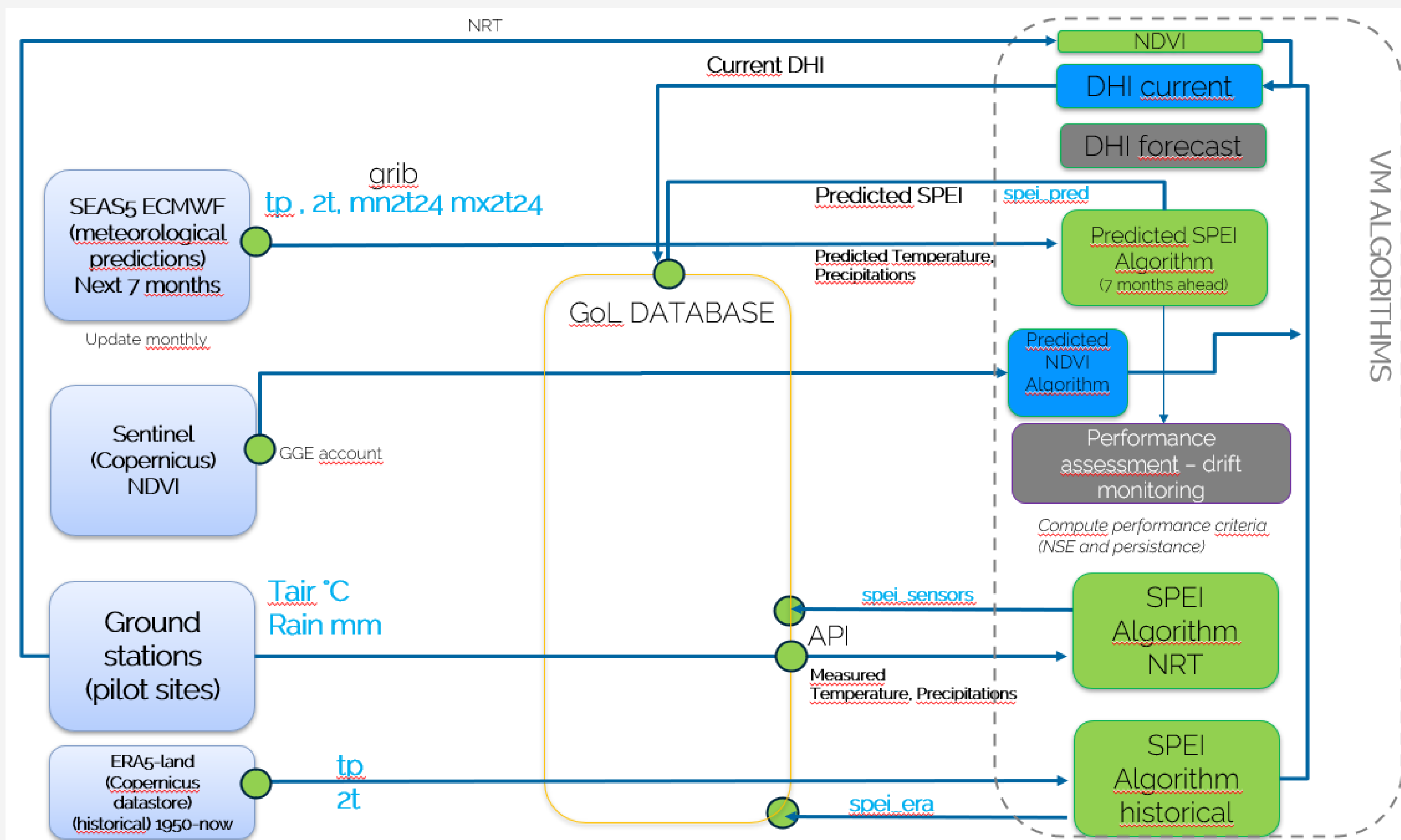
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Operationalisation : architecture choices



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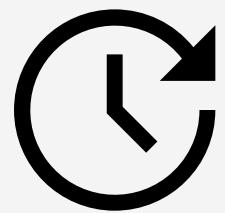


Conclusion and perspectives



Limits :

Short time series to validate from ground stations scales ERA5-Land & SEAS5
NDVI and NDVI anomalies dependant on ecosystems and validation by sensor is not telling the full story



Ongoing / next :

- Testing, validation, uncertainty quantification, bias correction ...
- Combined DHI indicator (SPEI, NDVI anomaly index and CWSI)
- Scale up : generalisation / transferability -> follow up program
 - Direct for SPEI and CWSI
 - More work to do on various ecosystems for NDVI models but a guide methodology



Also don't forget the humans behind the algorithms!

- Models : co-construction with public authorities /end users & researchers & IT
- Frugal models



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Thank You.



Code will be available via
Interreg EURO MED platform
(github repo)

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lea.duran@atos.net

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