

WATER BALANCE MODELING FOR TERROIR CHARACTERIZATION AND ADAPTIVE MANAGEMENT IN EXTREME VITICULTURE

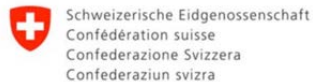
Tarditi M., Payan J.C., Reynard J.S., Verdenal T., Patono D.L.,
Lovisolo C., Ferrandino A., Zufferey V.



CERVIM CONGRESS - MONTREUX 6 - 8 MAY 2026



Doctoral school
National Doctorate in Food System



AGROSCOPE



The TERROIR

Mountain and terraced vineyards

Site-specific conditions

- Climatic variability
- SOIL: heterogeneity - depth, high skeleton content
- High spatial variability in soil water availability
- Variable water status of the vine (Ψ) across small spatial scales
- 👉 difficult to estimate available water and manage irrigation accurately



The importance of water status

- hydraulic signals and ABA -> photosynthesis
-> grape quality and composition

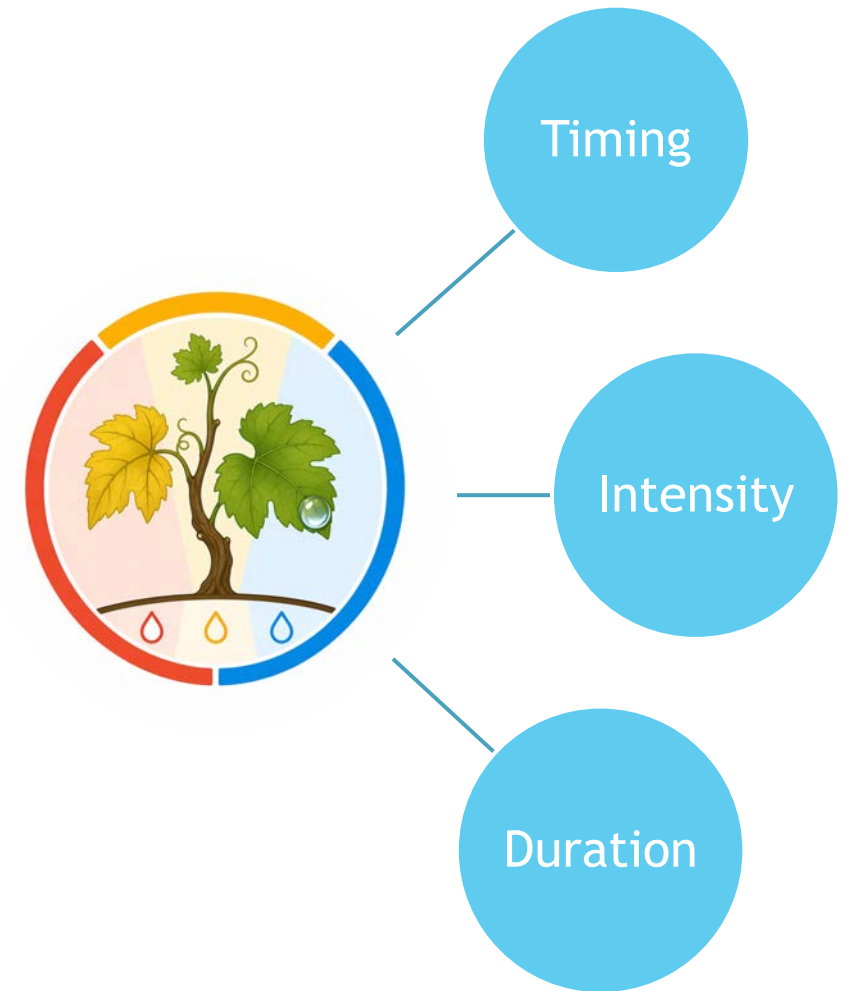
Water stress:

- Before fruit set -> reduction in berry number
- Between fruit set and veraison -> reduced berry weight and heterogeneity

High availability:

Negative effects on plant health, grape quality and wine quality

- impaired accumulation of sugars and pigments



THE IMPORTANCE OF DETERMINING AND PREDICTING THE WATER STATUS OF THE PLOT

- ❖ Direct measurements (Ψ)
- ❖ Water balance modelling

👉 **Aim** : MODELLING OF THE WATER BALANCE

The MODEL - IFV France - developed for Mediterranean conditions

➔ Application in an alpine environment

Testing transferability by estimating:

- ✓ soil water reserves
- ✓ seasonal dynamics



Materials and methods

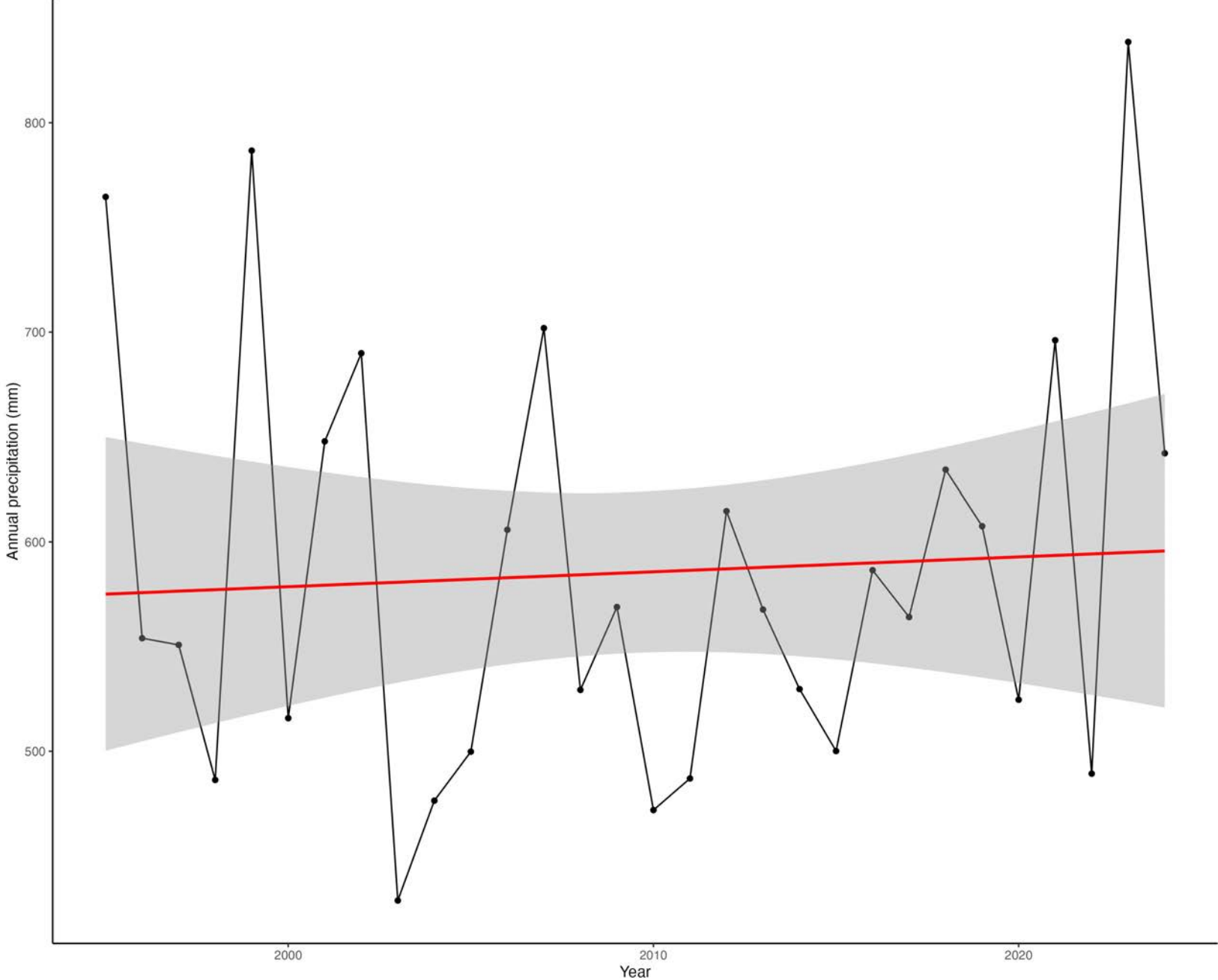
The Experimental Site Agroscope in Leytron, Wallis, Switzerland (46°10' N, 7°12' E, 485 m asl)

Characteristics of the plot:

- non-irrigated
- soils:
 - very stony (> 60% – Peyrosol)
 - low water-holding capacity (~150 mm)
 - deep vine rooting (> 2.5 m)
- alpine climate:
 - low rainfall
 - high solar radiation
 - frequent summer droughts



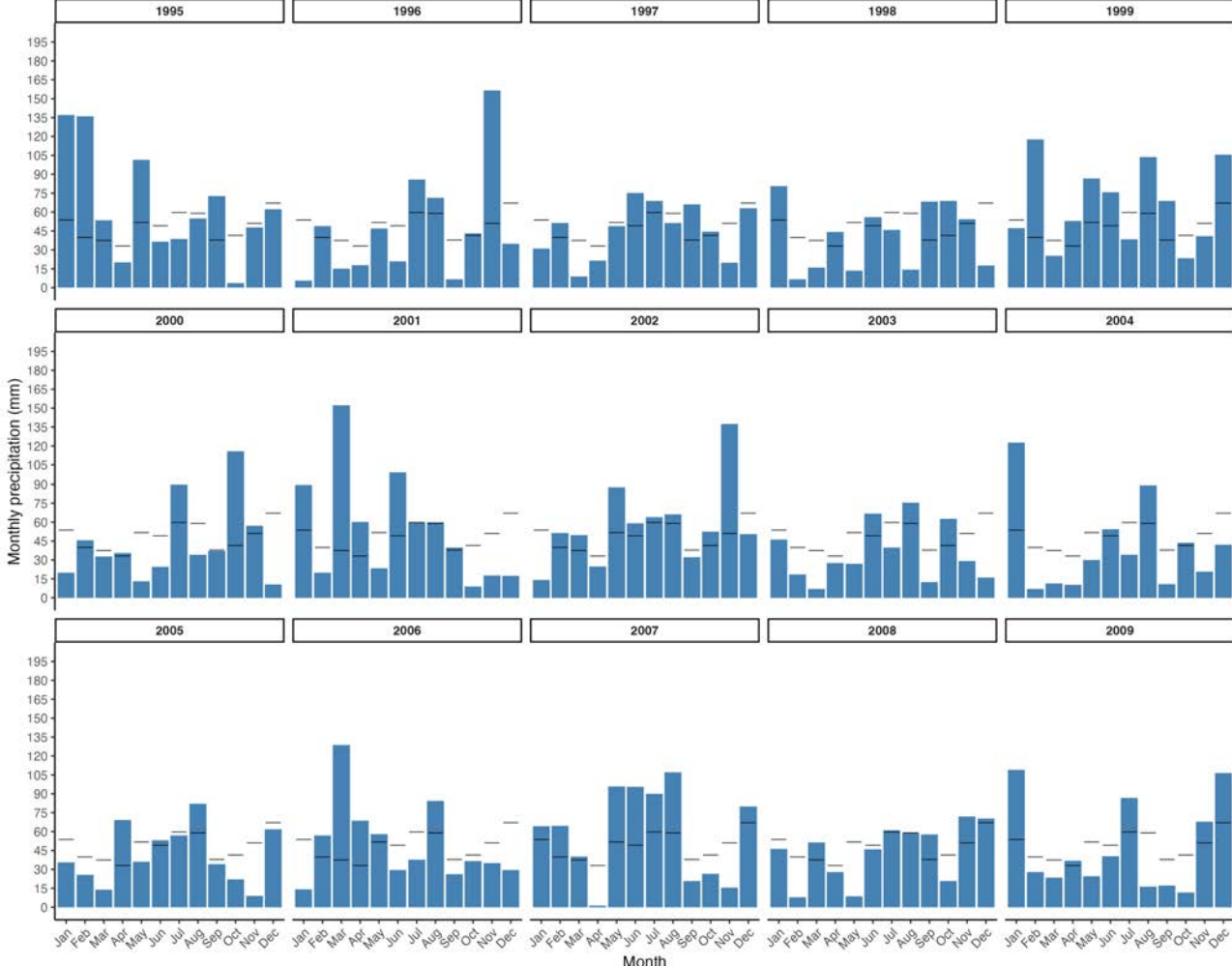
TREND OF ANNUAL PRECIPITATION 1995 - 2024



MONTHLY PRECIPITATION vs CLIMATOLOGY

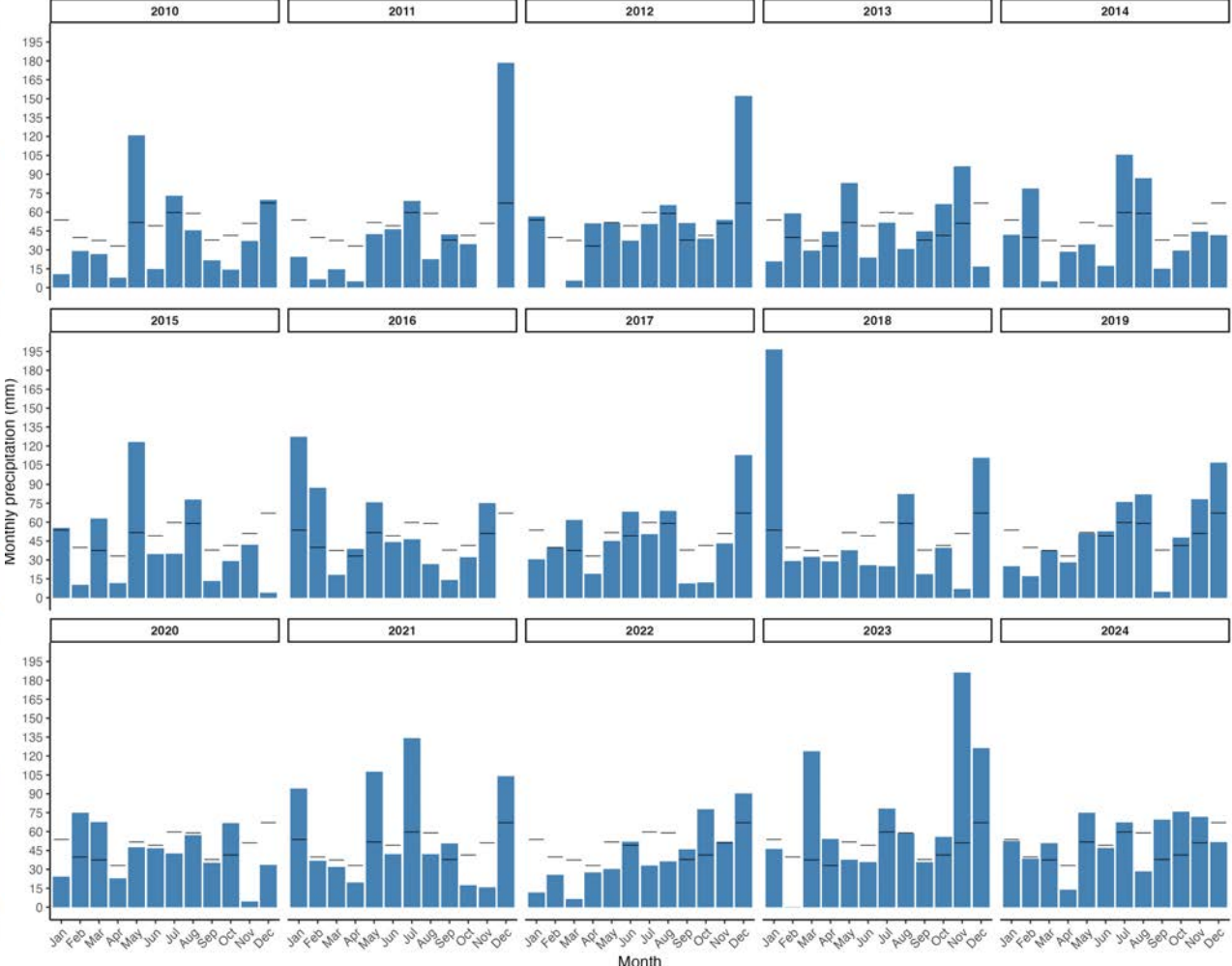
Monthly precipitation vs climatology (1995–2009)

Black line = 1991–2020 monthly mean



Monthly precipitation vs climatology (2010–2024)

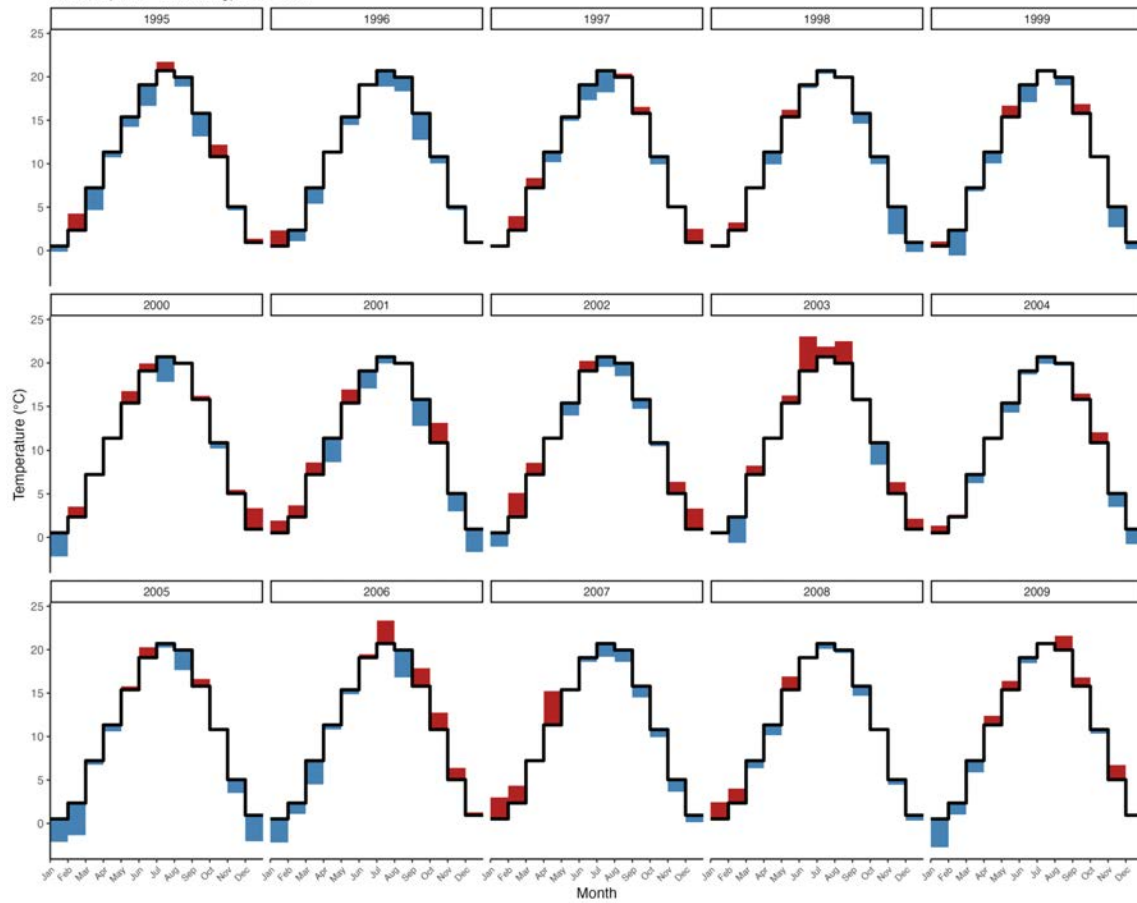
Black line = 1991–2020 monthly mean



MONTHLY MEAN TEMPERATURE ANOMALIES vs CLIMATOLOGY

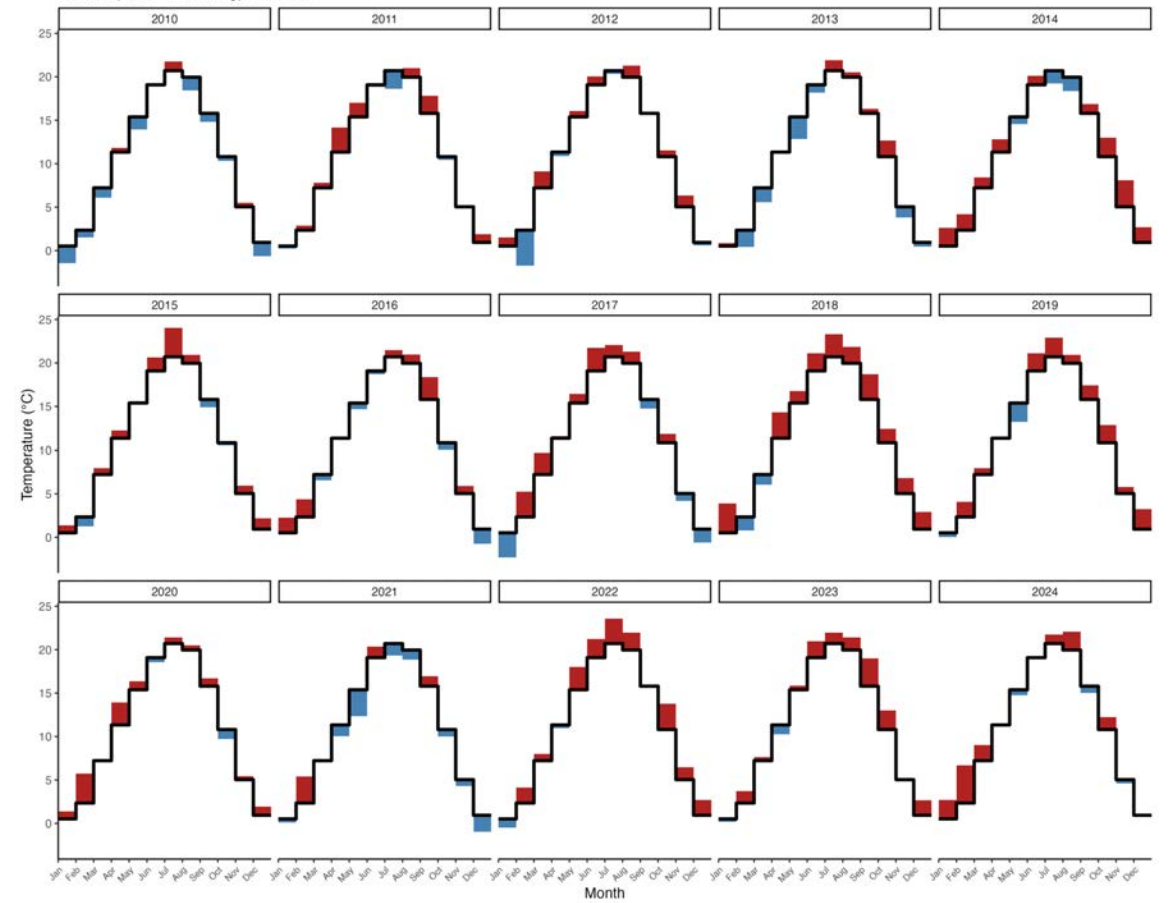
Monthly Mean Temperature Anomalies (1995–2009)

Black step line = Climatology 1991–2020



Monthly Mean Temperature Anomalies (2010–2024)

Black step line = Climatology 1991–2020



THE PLOT - Parameterisation and simulation

Vitis vinifera cv Chasselas (clone 14/33-4, rootstock K5BB)

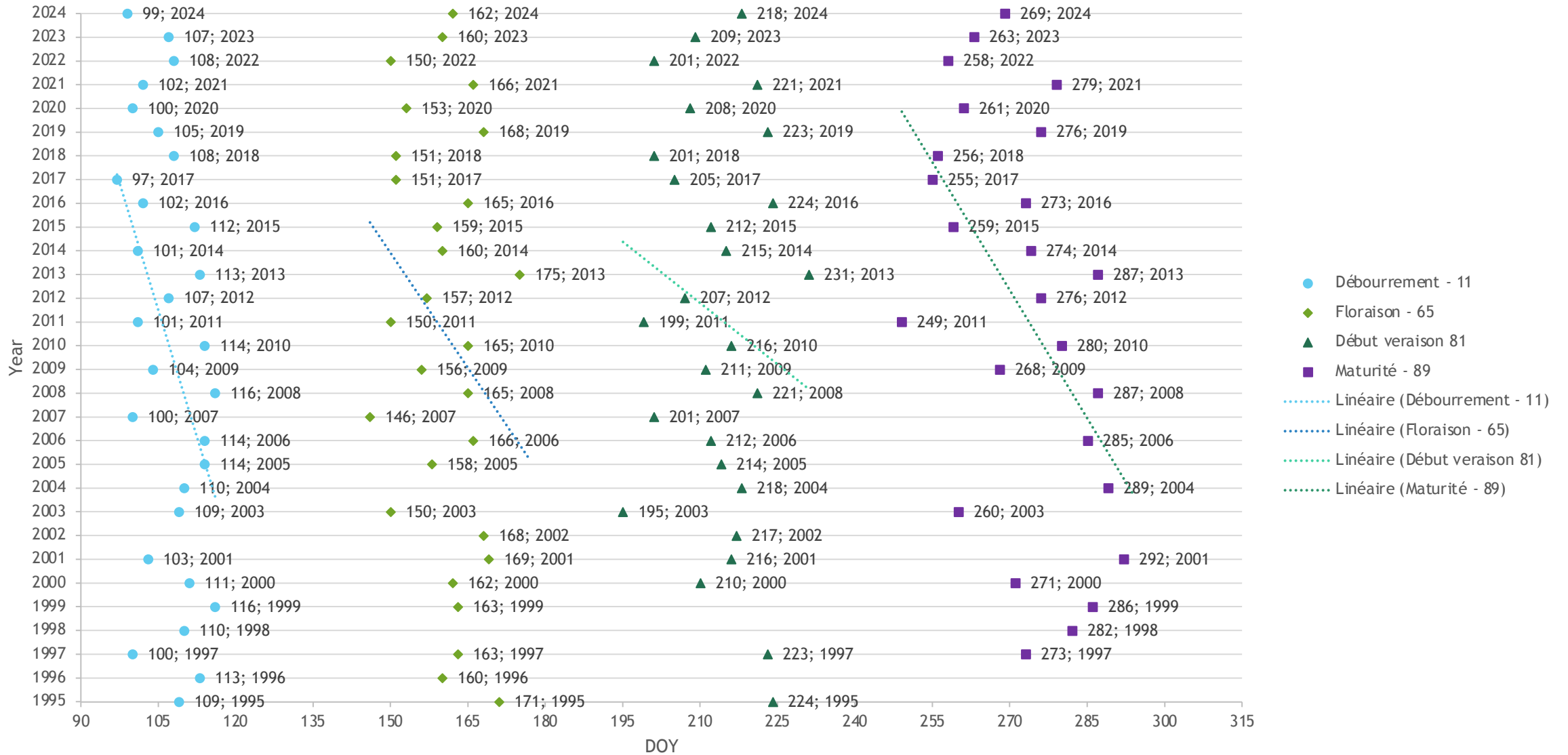
Measurements on adult vines ->

Dataset of 30 years 1995–2024 measures:

- ✓ predawn leaf water potential (PLWP)
- ✓ daily weather data:
 - i. temperature
 - ii. precipitation
 - iii. ET_o (Turc method)
- ✓ Canopy geometry (leaf area exposed to sunlight, porosity, planting density)
- ✓ Phenological stages



Phenological stages 1995-2024



MODELLING OF THE WATER BALANCE

Parameterisation and simulation

Other variables included in the model:

- Maximum crop coefficient (Kmax)

-> **RytVigne** sub-model for the dynamic estimation of Kmax:

- intercepted radiation
- vineyard structure
- latitude, longitude, albedo

Simulation: 1995–2024 annually using PLWP data

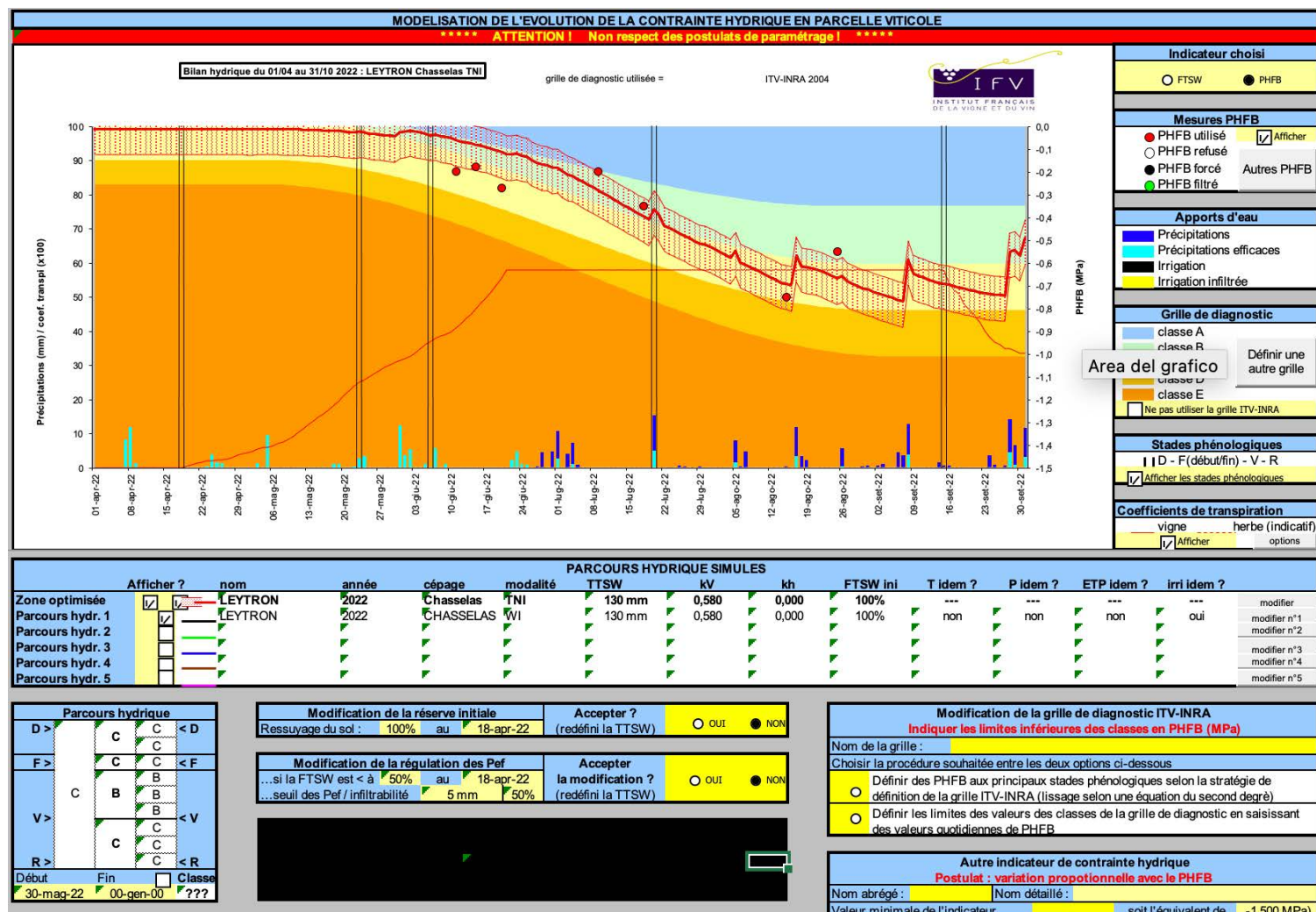
Validation:

- comparison with field-measured water-holding capacity
- assessment of the RMSE (Root Mean Squared Error)

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SEASONAL TRENDS IN THE WATER BALANCE

- Measured vs simulated PLWP
- Identification of water stress levels
- Evapotranspiration
- Effective vs non-effective precipitation
- Link to phenological stages



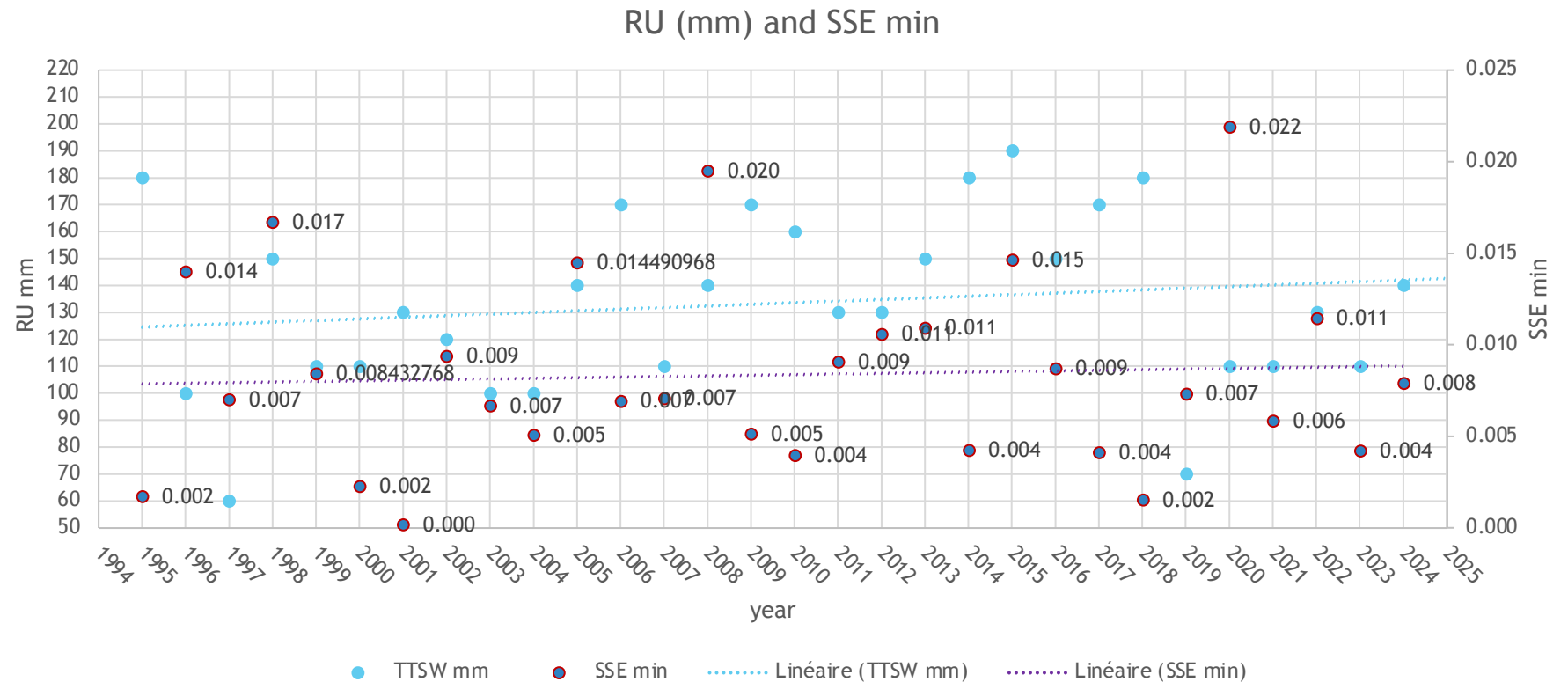
Results

ESTIMATE OF WATER RESERVES (TTSW) and Sum of Squared Errors (SSE)

- Significant year-to-year variability
- Averages consistent with field data
- 👉 Good long-term estimate

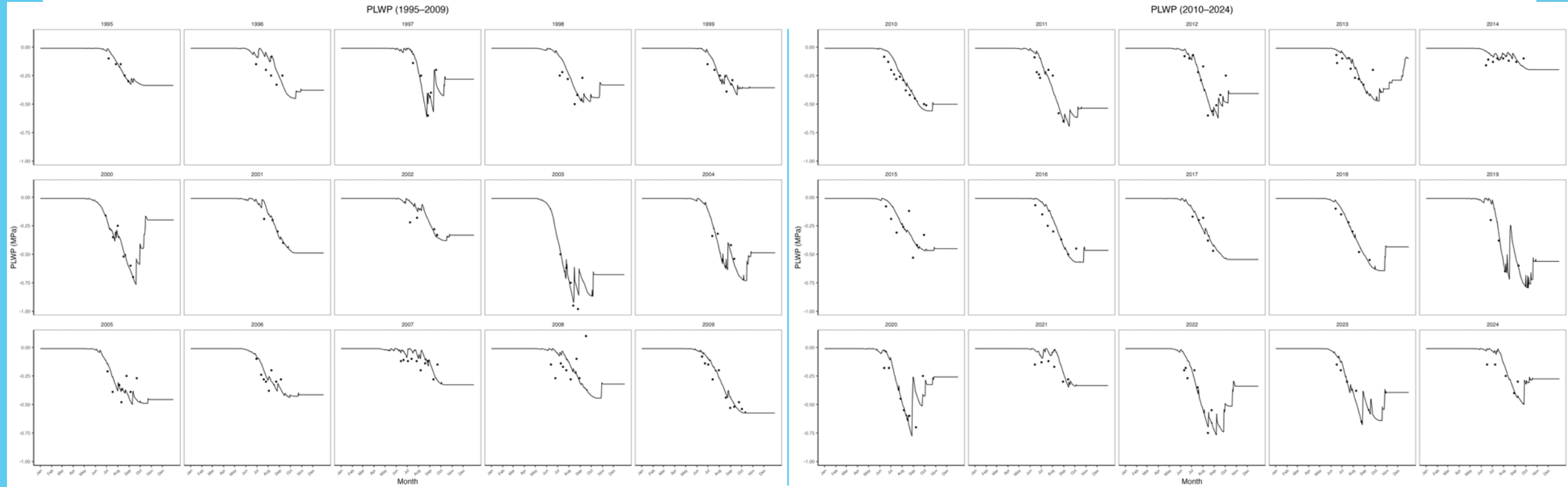
⚠️ Limitations:

- short-term fluctuations
- difficulty in estimating precise absolute values



Results

TRENDS IN THE WATER BALANCE of 30 YEARS DATA



- Measured PLWP values
- PLWP values estimated by the model

Results

MODEL PERFORMANCE

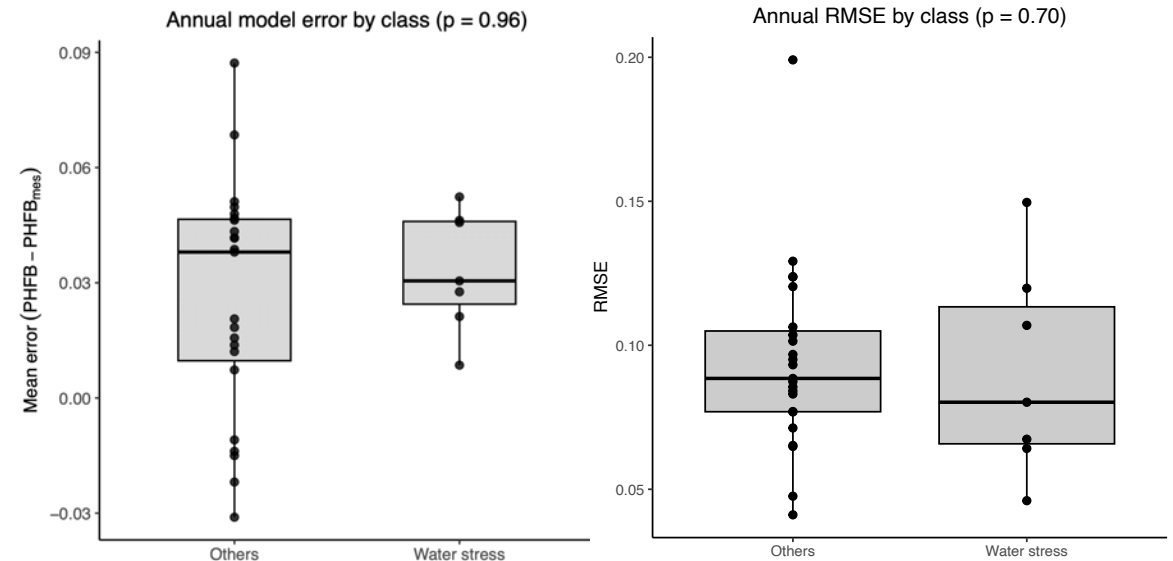
Reconstruction of the water balance over 30 years:

- ✓ Good representation of seasonal dynamics
- ✓ Strong consistency between simulated water status and PLWP measurements
- ✓ The model captures the temporal variability of water stress
- ✓ The model tends (Wilcoxon test) to be more accurate in warmer years (2003, 2009, 2011, 2017, 2018, 2020, 2022)

Variables to be adjusted – set in the Alpine context:

- **Kmax**
- as outlook : **Useful rainfall**

Measures	Mean bias MPa	RMSE (Root mean square error) MPa	MAE (mean absolute error) MPa
200	0.027	0.101	0.081



IMPLICATIONS FOR VITICULTURE

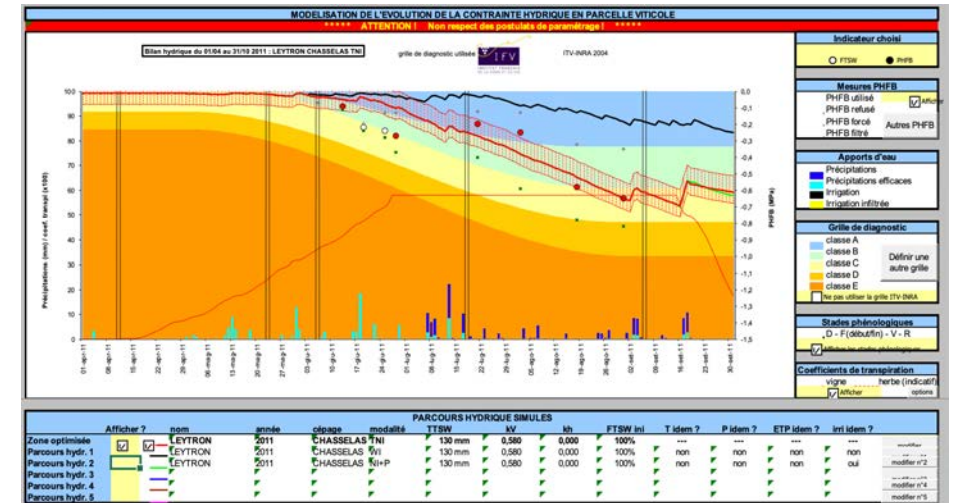
- ✓ Identification of critical periods during the growing season
 - > retrospectively
- ✓ Reduction in field measurements : 3 measures
- ✓ characterisation of the vineyard over several years

Perspectives

- rational irrigation
- soil management practices and
- vegetation cover management
- biostimulants

➔ Further validations

- > 10 years data from the plot with different water conditions (non irrigated, irrigated, induced water stress)
- > tests on network plots in the Valais vineyards

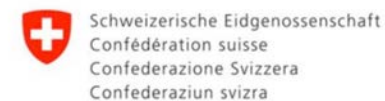
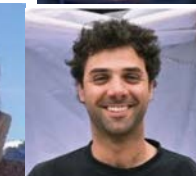




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THANK YOU FOR YOUR ATTENTION

martina.tarditi@unito.it



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