



TIME-DEPENDENT SENSITIVITY AND UNCERTAINTY ANALYSES
OF AN AGRO-CLIMATIC MODEL
FOR THE WATER STATUS MANAGEMENT OF VINEYARD

Anaïs Guaus

Eric Lebon

Frédéric Gérard

INRA

Montpellier, France

Aline Bsaibes

Thomas Cartailier

ITK

Montpellier, France

Clémentine Prieur

Joseph Fourier University

Grenoble, France



CONTEXT : **DISP** eau PROJECT

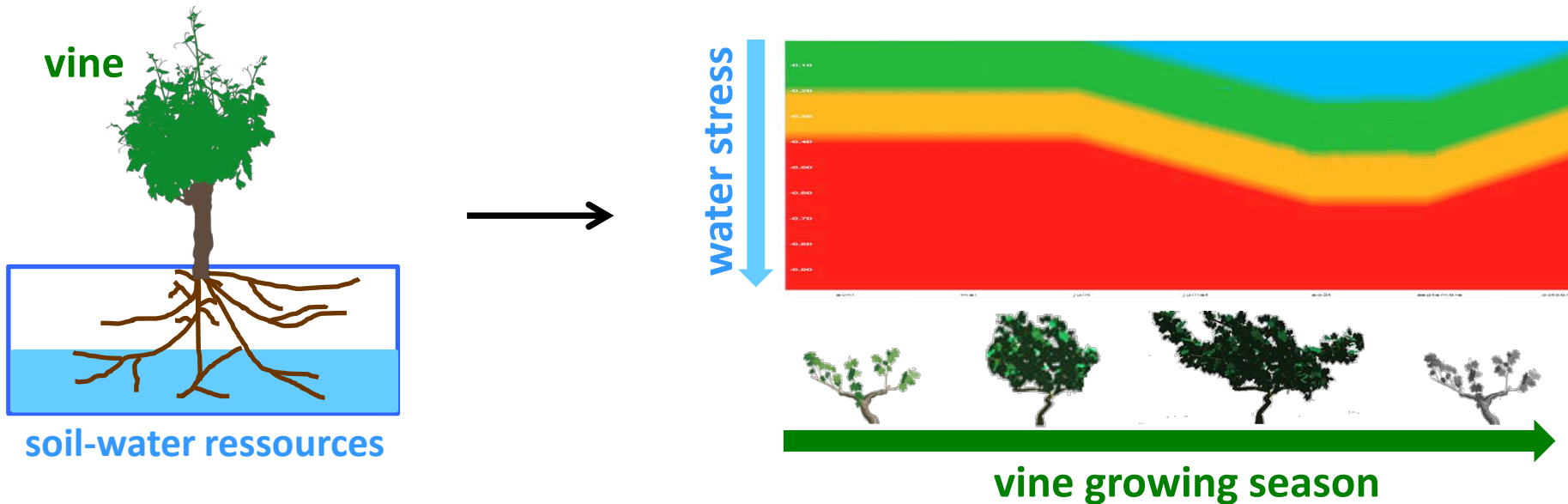
- **Project objective:** control of **grape/wine quality**

→ **quality** ↔ **water stress dynamics**

→ **water management** of vineyard



- **Modelling of the water stress (= vine thirst) dynamics**



CONTEXT : **DISP** eau PROJECT

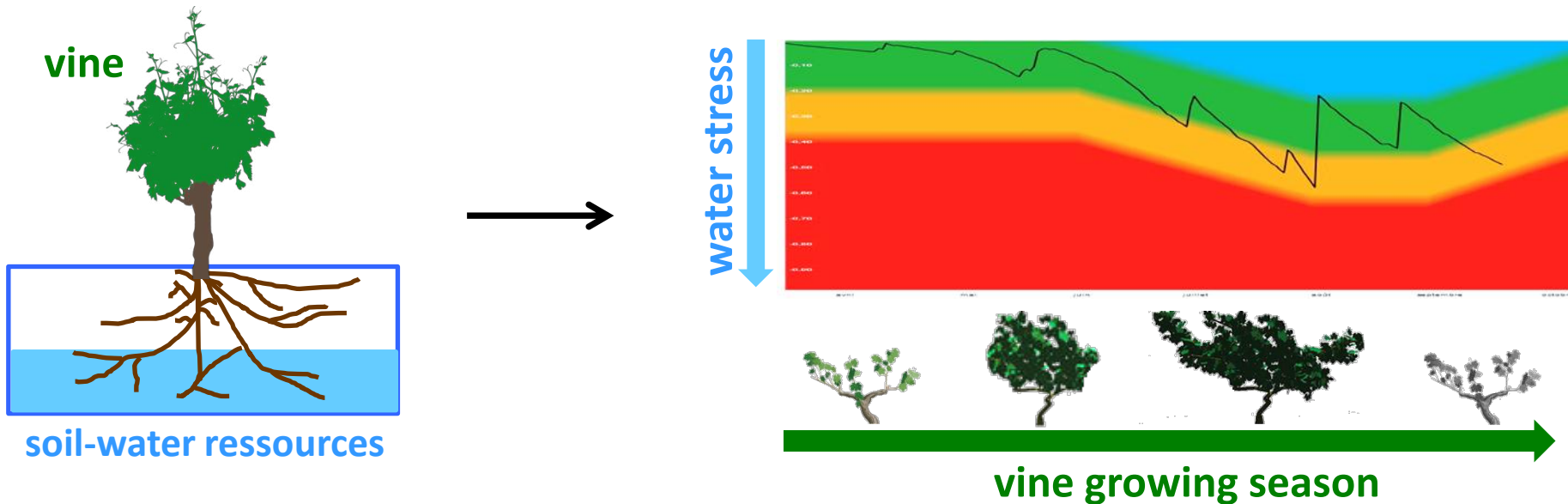
- **Project objective:** control of **grape/wine quality**

→ **quality** ↔ **water stress dynamics**

→ **water management** of vineyard



- **Modelling of the water stress (= vine thirst) dynamics**



CONTEXT : **DISP** eau PROJECT

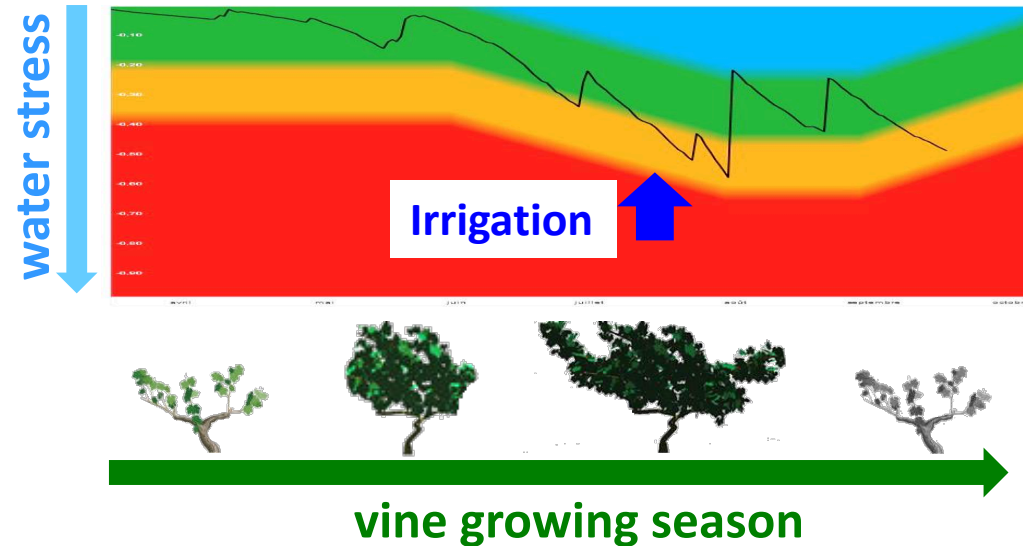
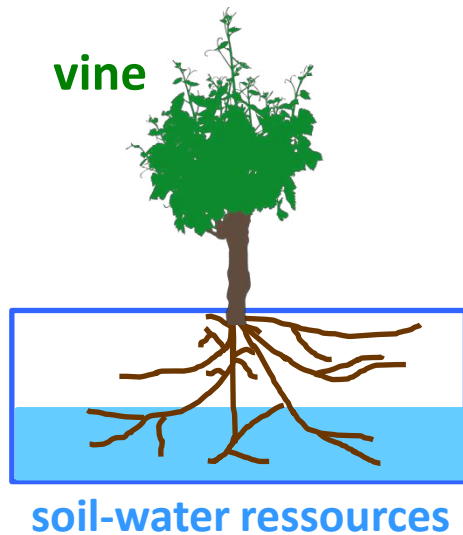
- **Project objective:** control of **grape/wine quality**

→ **quality** ↔ **water stress dynamics**

→ **water management** of vineyard



- **Modelling of the water stress (= vine thirst) dynamics**

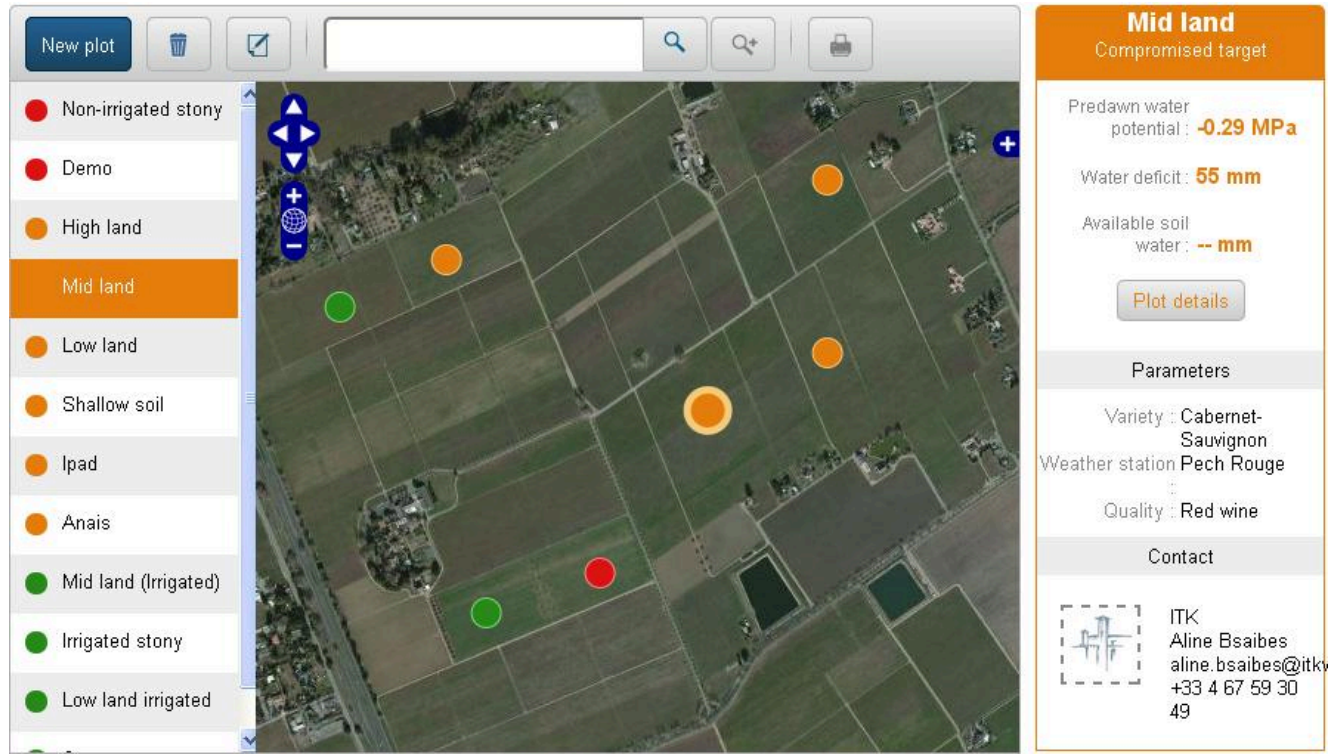


CONTEXT : PROJECT

- WEB APP developed by  : www.dispeau.com
Expert software for agriculture

- End-users = winegrowers

- Decision-Support System → water management for each vine-plot (ex: irrigation)



The screenshot displays the DISPeau web application interface. On the left, a legend lists various plot types with corresponding colored circles: Non-irrigated stony (red), Demo (red), High land (orange), Mid land (orange), Low land (orange), Shallow soil (orange), Ipad (orange), Anais (orange), Mid land (Irrigated) (green), Irrigated stony (green), and Low land irrigated (green). The 'Mid land' category is currently selected. The main area shows an aerial map of a vineyard with several colored circles representing different plots. On the right, a detailed data panel for a 'Mid land' plot is shown, indicating it is a 'Compromised target'. The panel includes the following information:

- Predawn water potential: **-0.29 MPa**
- Water deficit: **55 mm**
- Available soil water: **-- mm**
- Plot details button
- Parameters section:
 - Variety: Cabernet-Sauvignon
 - Weather station: Pech Rouge
 - Quality: Red wine
- Contact section:
 - ITK
 - Aline Bsaibes
 - aline.bsaibes@itk
 - +33 4 67 59 30 49



CONTEXT : **DISP** eau PROJECT

• **WEB APP** developed by **ITK** : www.dispeau.com
Expert software for agriculture

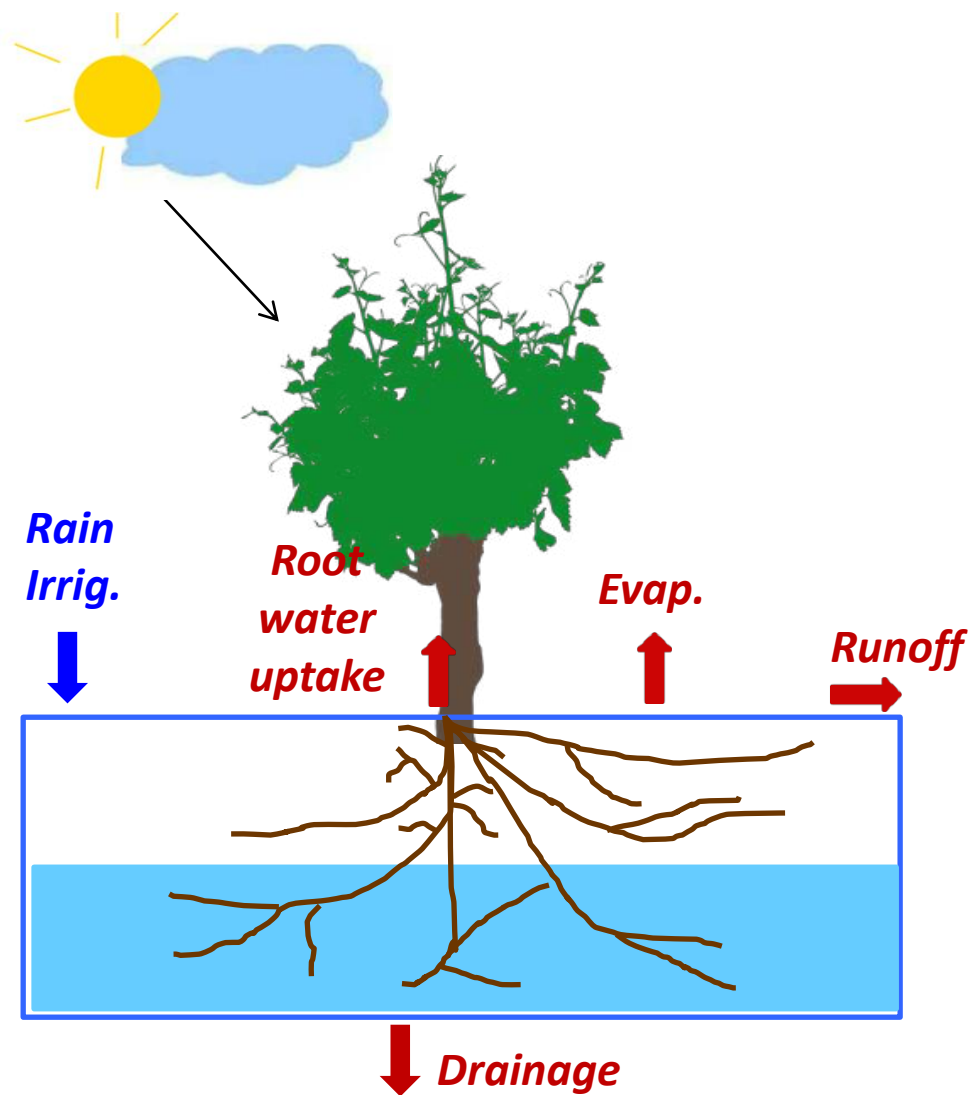
• **End-users = winegrowers**

• **Decision-Support System** → **water management for each vine-plot (ex: irrigation)**

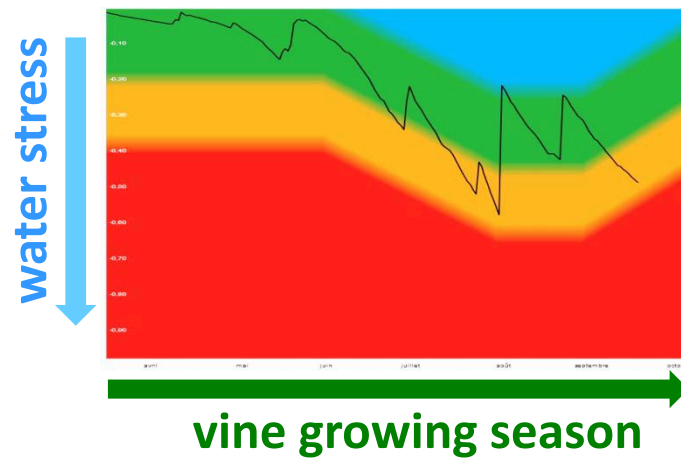


AGRO-CLIMATIC MODEL

Water budget



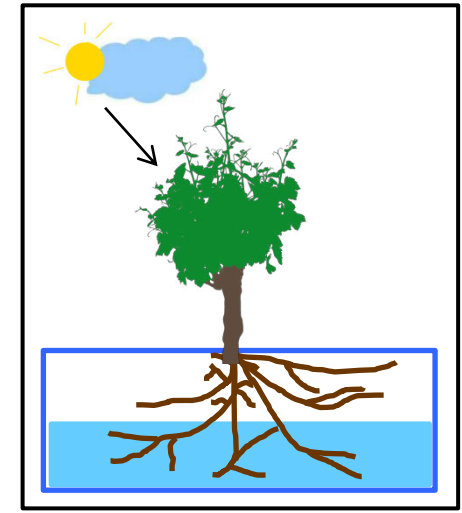
Daily output



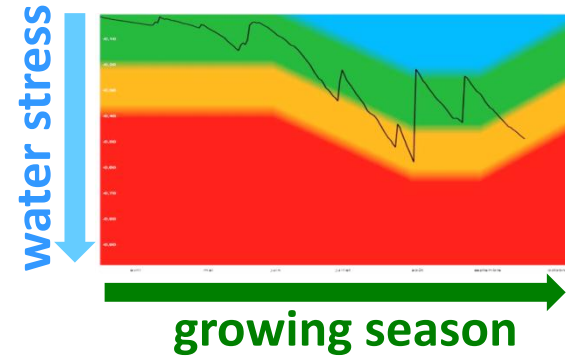
INPUTS

- Vine-plot
- Weather data during the growing season

Water budget



Daily output



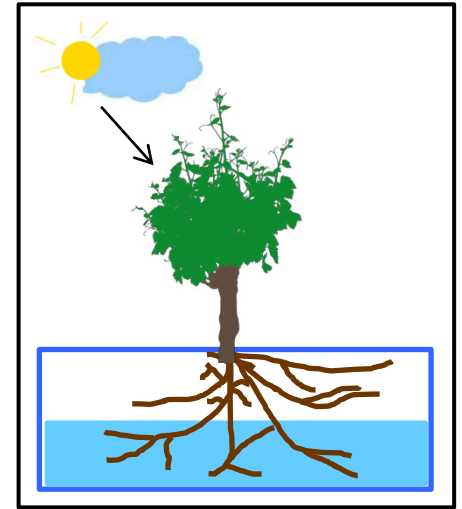
INPUTS

- Vine-plot

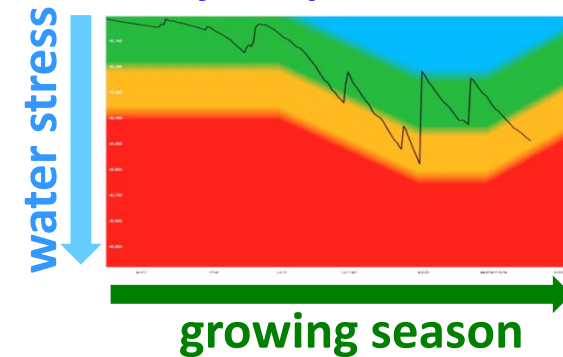
➔ 22 scalar parameters: soil texture, rooting depth, vegetation size, row orientation, ...

- Weather data during the growing season

Water budget



Daily output



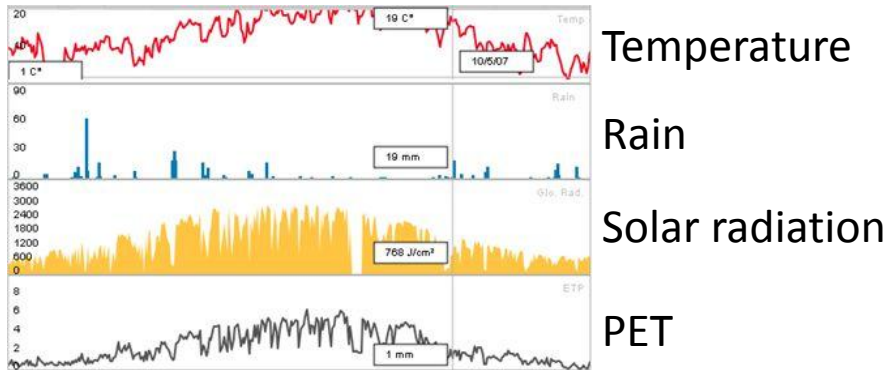
INPUTS

- Vine-plot

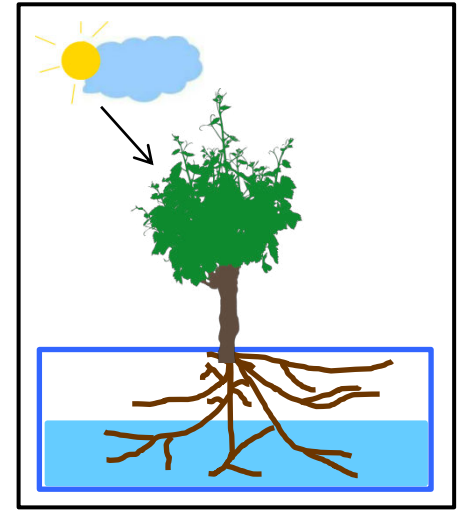
➔ 22 scalar parameters: soil texture, rooting depth, vegetation size, row orientation, ...

- Weather data during the growing season

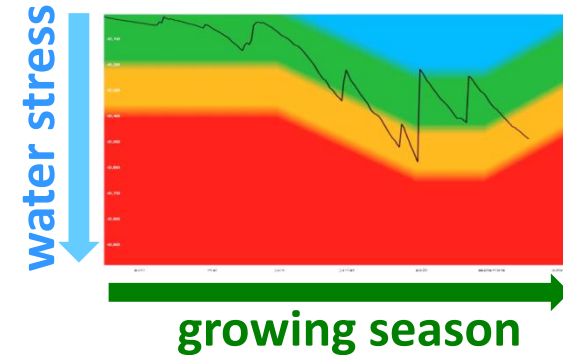
➔ 4 correlated (daily) functional inputs



Water budget



Daily output



SA METHOD

- Model in Matlab (0.4 sec./simu)
- Fixing of 6 scalar factors via Morris method
- SA via **Sobol method** (*Saltelli et al., 2002*)



WHAT WE DID

- SA at the Languedoc-Roussillon regional scale
- SA at the vine-plot scale



SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

- ➔ **Region with strong water stress during summer**
- ➔ **Model general behavior**



SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

➔ Region with strong water stress during summer

➔ Model general behavior

• Vine-plot parameter distributions: regional variability



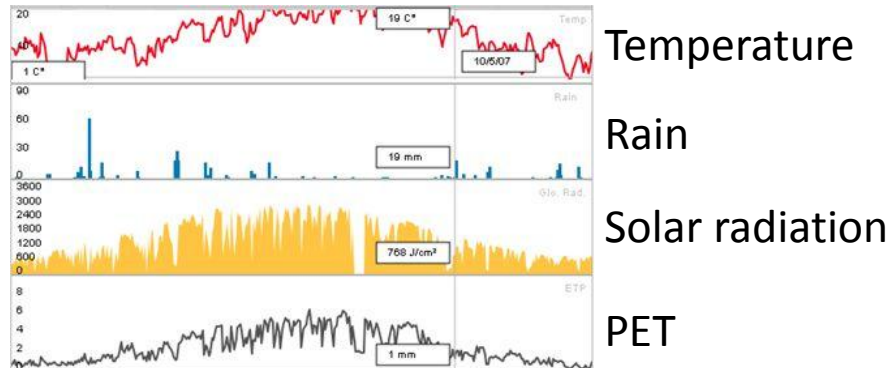
SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

➔ Region with strong water stress during summer

➔ Model general behavior

• Vine-plot parameter distributions: regional variability

• Weather influence as a whole:



SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

➔ Region with strong water stress during summer

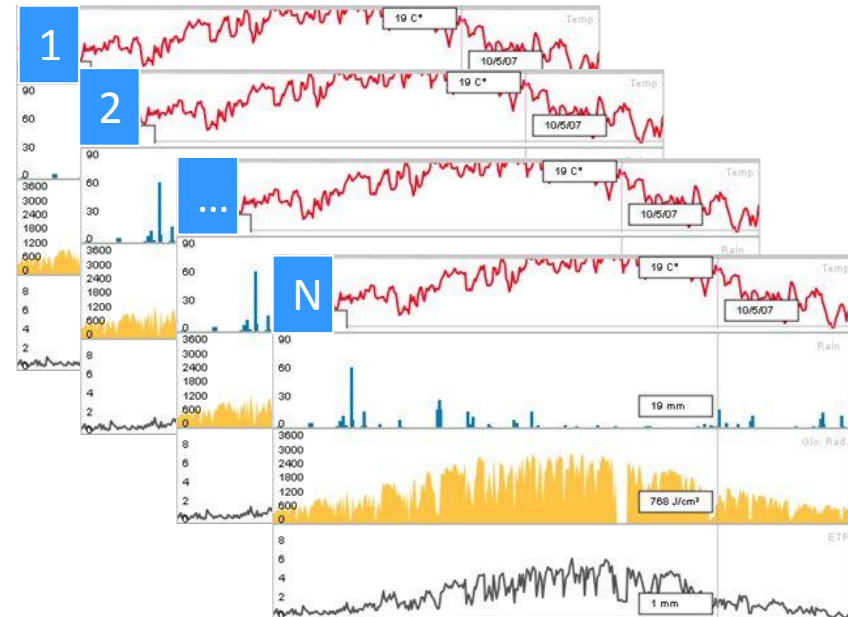
➔ Model general behavior

• Vine-plot parameter distributions: regional variability

• Weather influence as a whole:

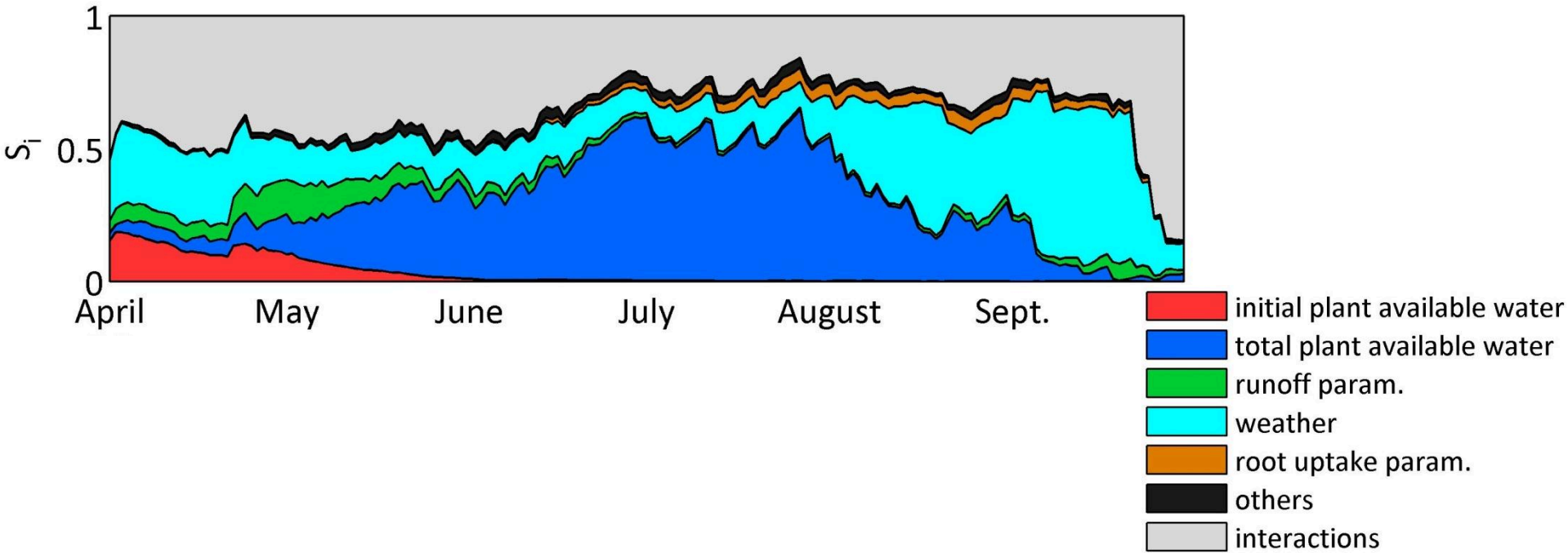
Map-labelling method
(Lilburne & Tarantola, 2009):

- ➔ N=22 sets of weather series
- ➔ Different years/spots, Languedoc-Roussillon region, France
- ➔ Equiprobable random sampling



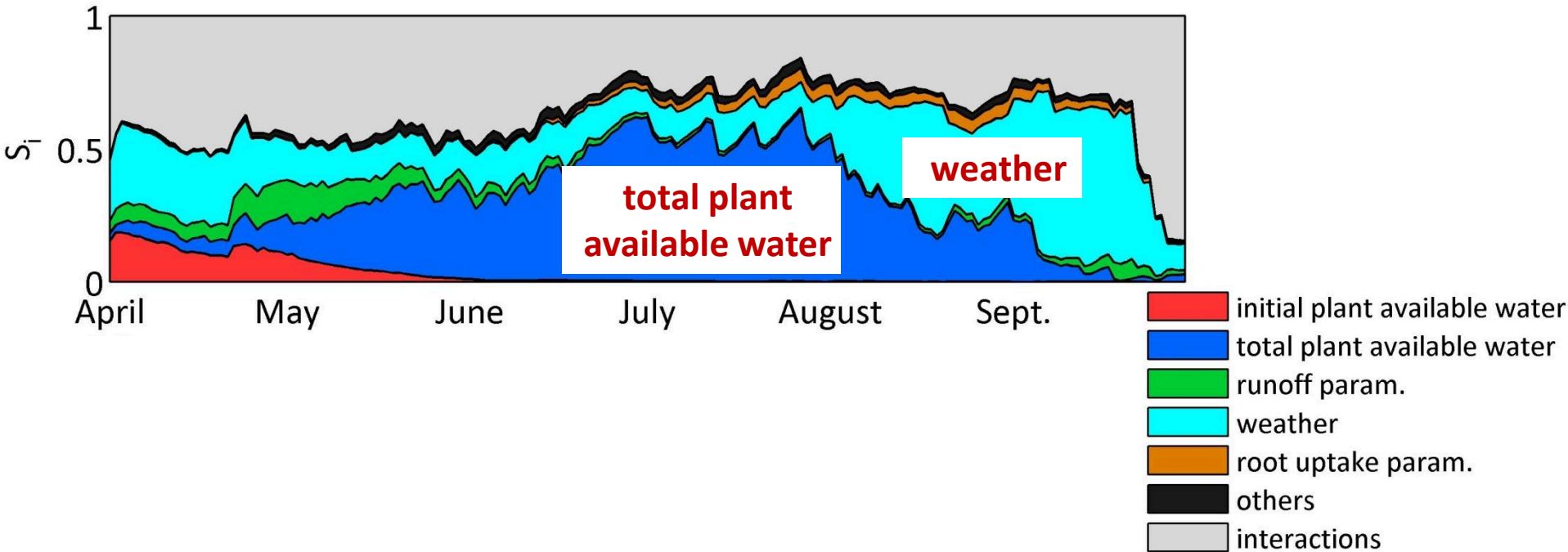
SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

Sobol 1st order indices : daily area chart



SA AT THE LANGUEDOC-ROUSSILLON REGIONAL SCALE

Sobol 1st order indices : daily area chart



→ Large influence of $\left\{ \begin{array}{l} \text{the total plant available water} \\ \text{the weather} \end{array} \right.$



SA METHOD

- SA at the Languedoc-Roussillon regional scale
- SA at the vine-plot scale



SA AT THE VINE-PLOT SCALE

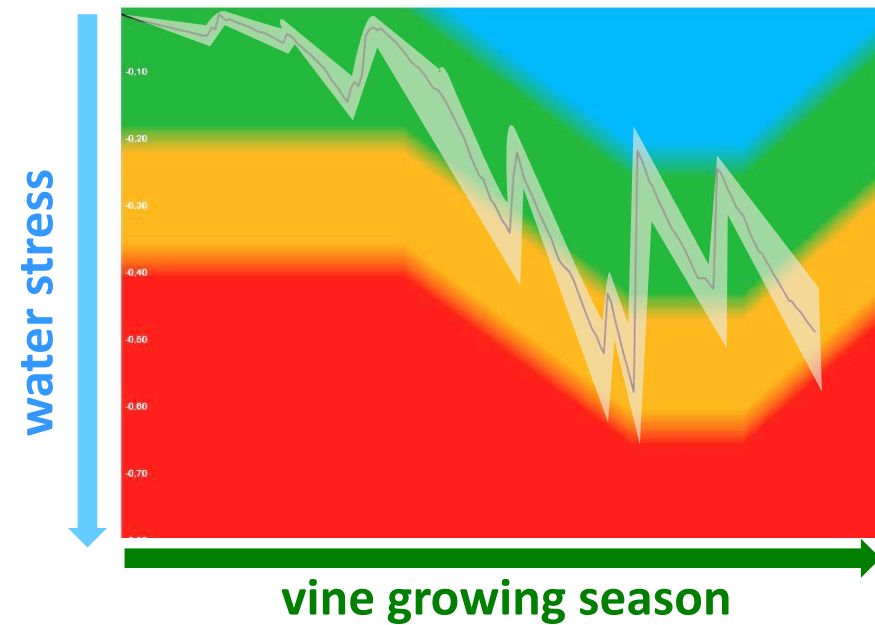
➔ Parameters given by the winegrowers

➔ Influence of the error
on parameter estimation

➔ Communication with the end-user

➔ Output uncertainty

➔ Calibration?



SA AT THE VINE-PLOT SCALE

➔ Parameters given by the winegrowers

➔ Influence of the error
on parameter estimation

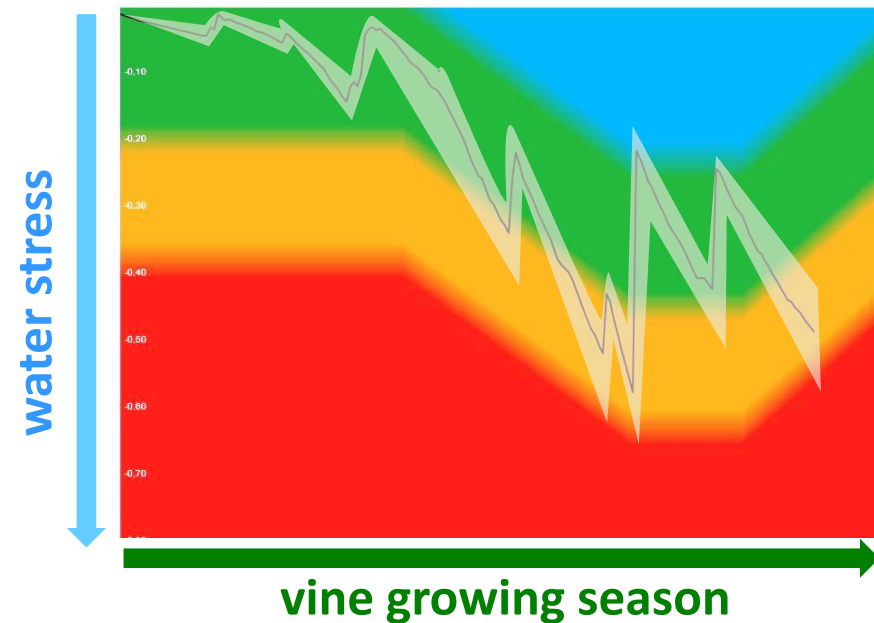
➔ Communication with the end-user

➔ Output uncertainty

➔ Calibration?

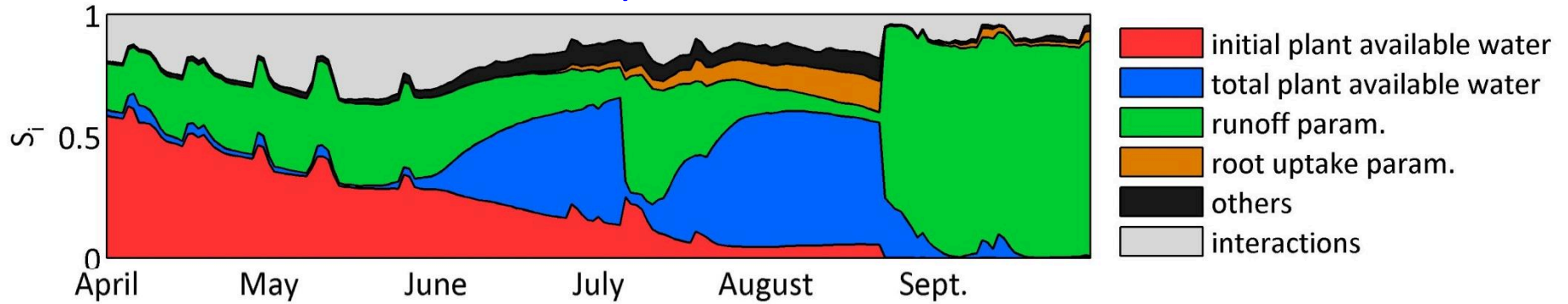
➔ SA repeated for 12 vine-plots x 3 weather series

- dry
- medium-dry
- humid



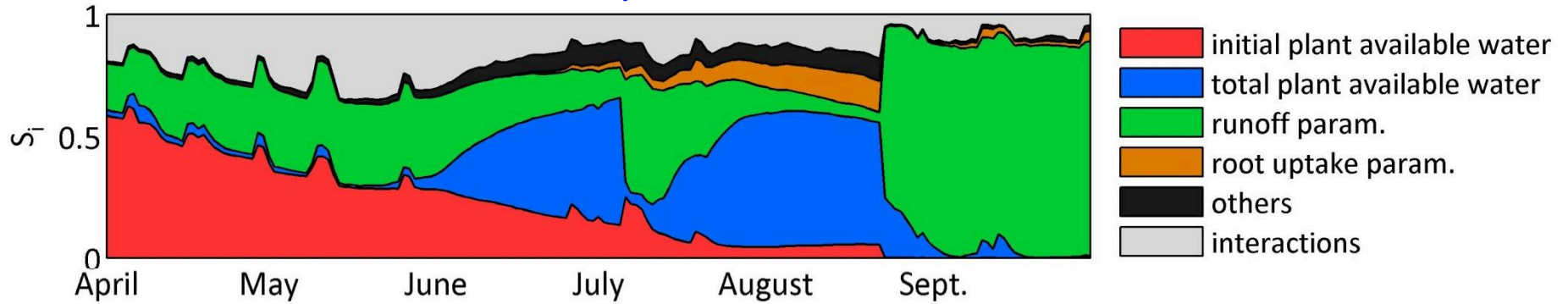
SA AT THE VINE-PLOT SCALE

Sobol 1st order indices : daily area chart



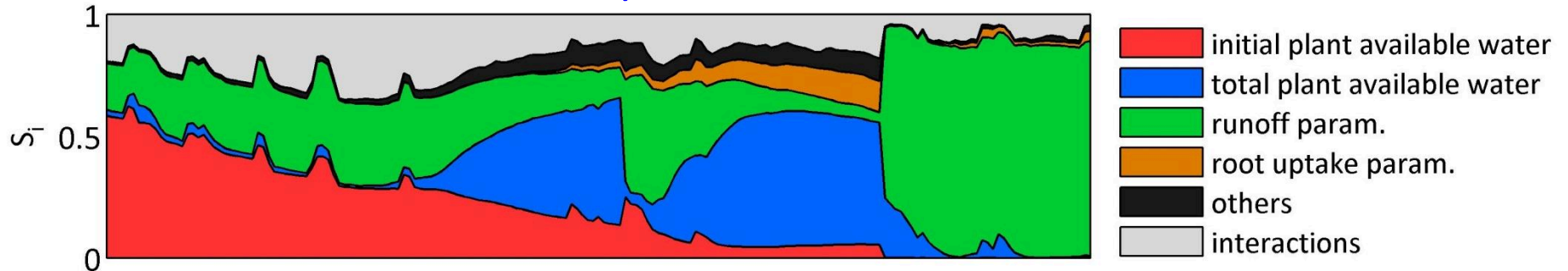
SA AT THE VINE-PLOT SCALE

Sobol 1st order indices : daily area chart

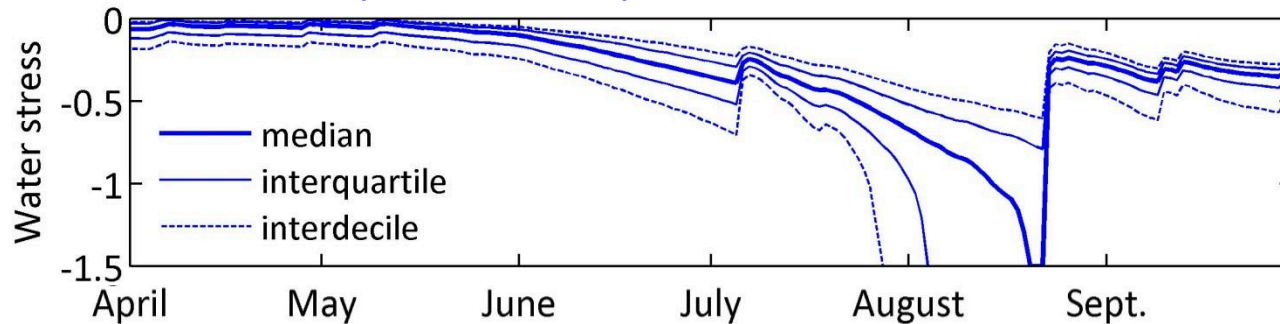


SA AT THE VINE-PLOT SCALE

Sobol 1st order indices : daily area chart

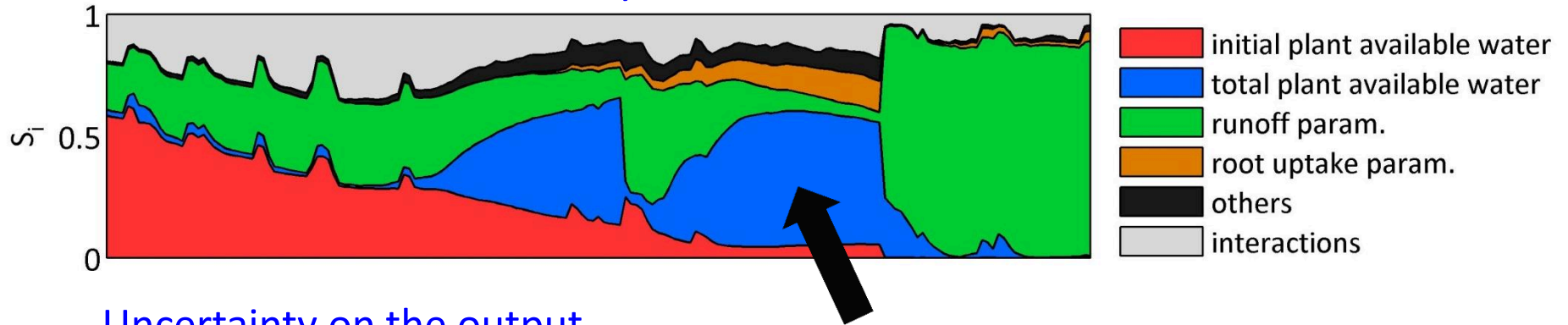


Uncertainty on the output



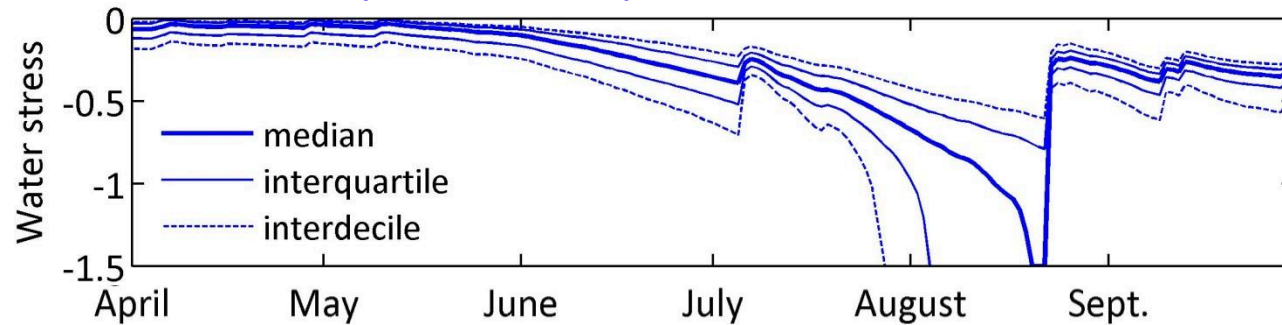
SA AT THE VINE-PLOT SCALE

Sobol 1st order indices : daily area chart



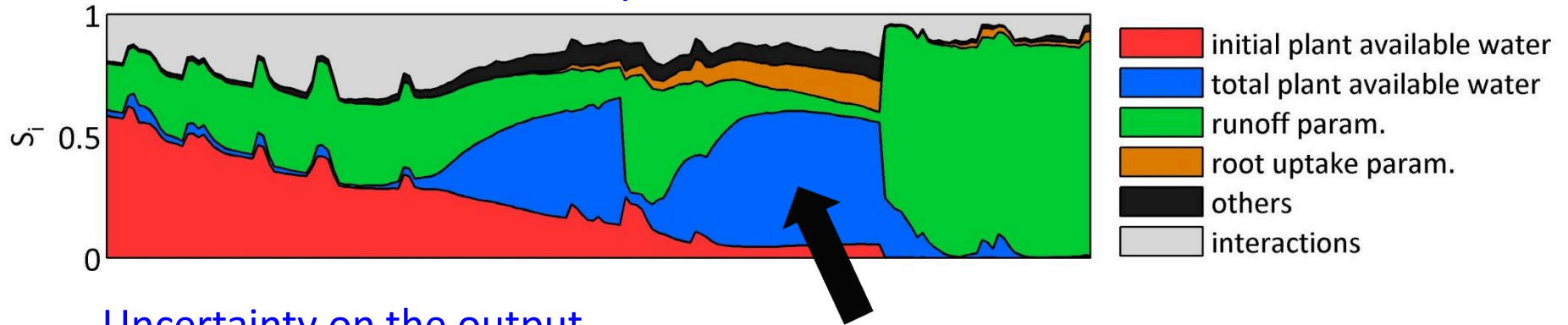
- initial plant available water
- total plant available water
- runoff param.
- root uptake param.
- others
- interactions

Uncertainty on the output

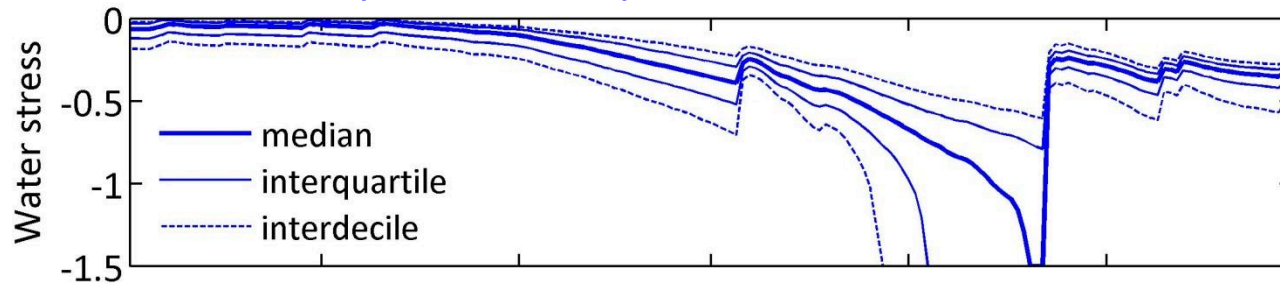


SA AT THE VINE-PLOT SCALE

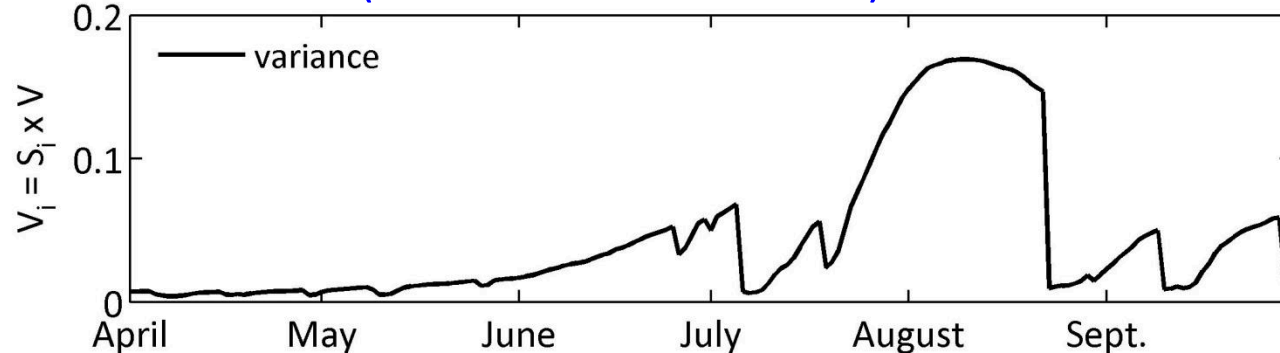
Sobol 1st order indices : daily area chart



Uncertainty on the output

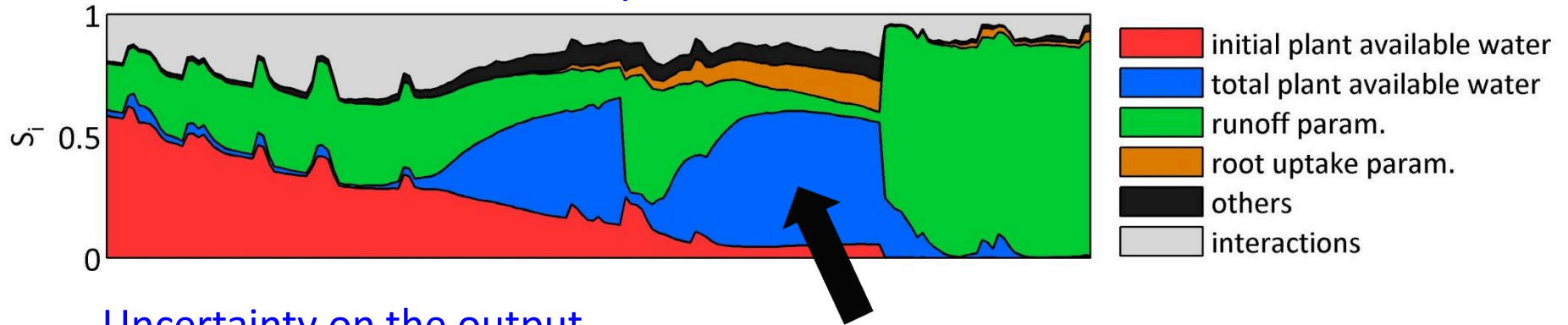


Variance x (Sobol 1st order indices)

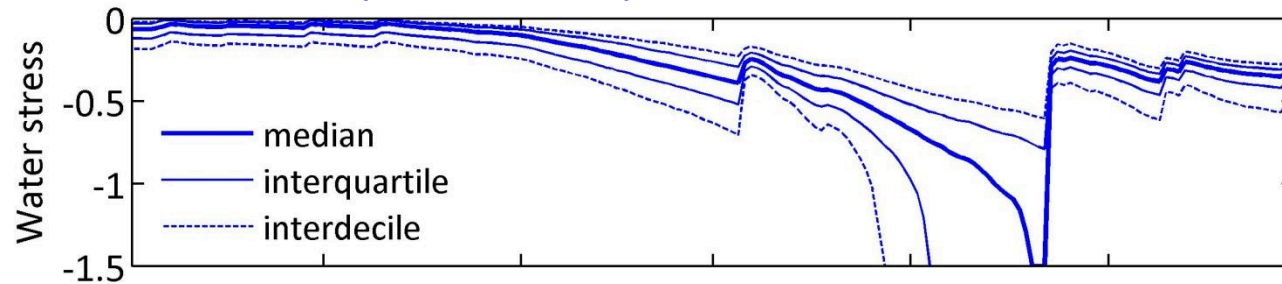


SA AT THE VINE-PLOT SCALE

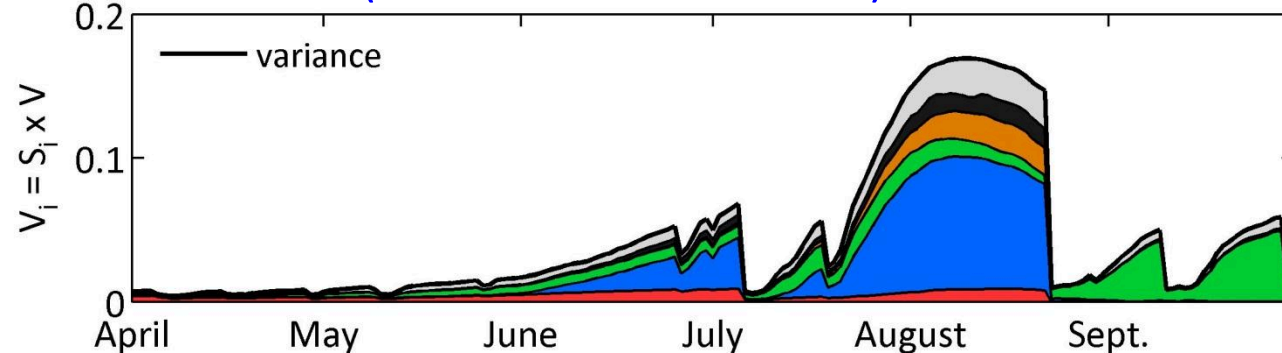
Sobol 1st order indices : daily area chart



Uncertainty on the output



Variance x (Sobol 1st order indices)



$$S_i = \frac{V_i}{V}$$



SA AT THE VINE-PLOT SCALE

Generalized sensitivity indices
(Lamboni et al., 2011):

$$\left\{ \begin{array}{l} GS_i = \frac{\sum_d S_i(d) \cdot V(d)}{\sum_d V(d)} \\ GST_i = \frac{\sum_d ST_i(d) \cdot V(d)}{\sum_d V(d)} \end{array} \right.$$



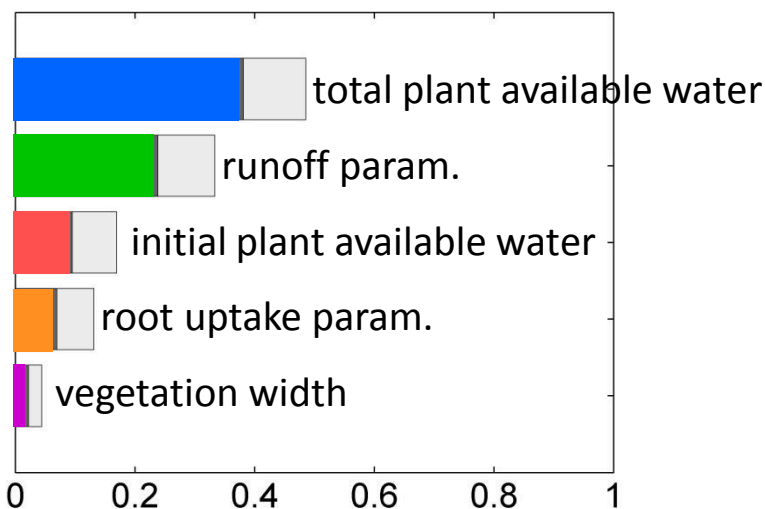
SA AT THE VINE-PLOT SCALE

Generalized sensitivity indices
(Lamboni et al., 2011):

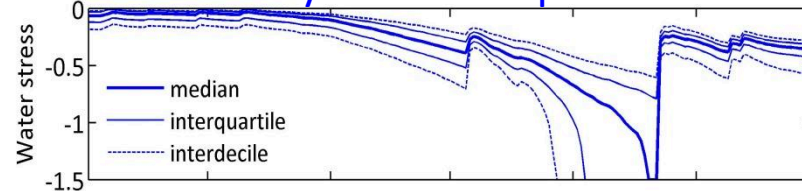
$$GS_i = \frac{\sum_d S_i(d) \cdot V(d)}{\sum_d V(d)}$$

$$GST_i = \frac{\sum_d ST_i(d) \cdot V(d)}{\sum_d V(d)}$$

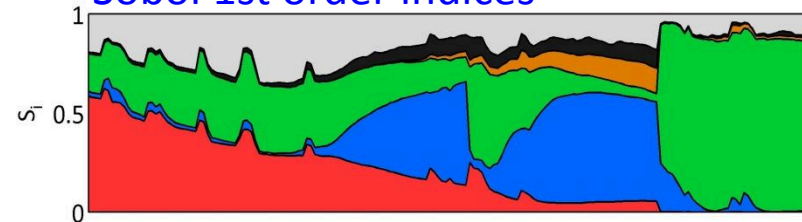
Parameter ranking



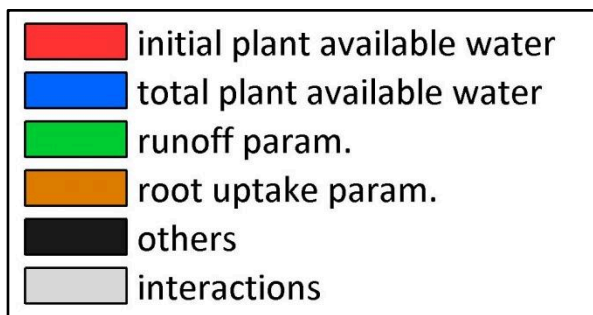
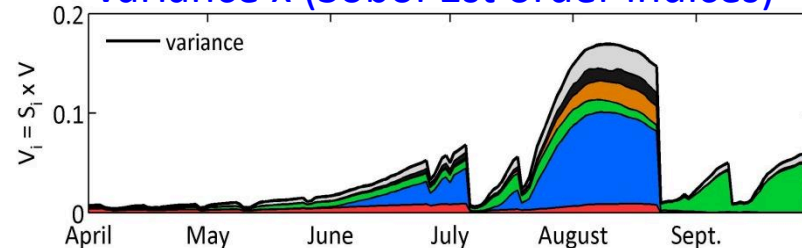
Uncertainty on the output



Sobol 1st order indices



Variance x (Sobol 1st order indices)



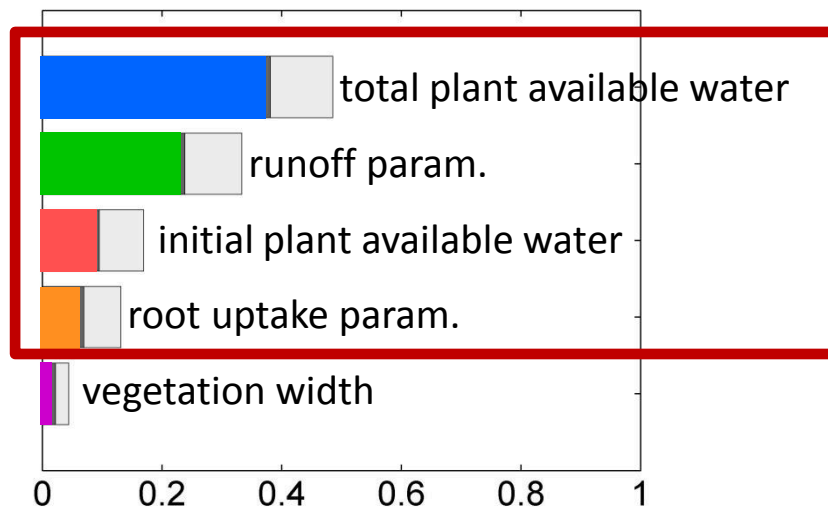
SA AT THE VINE-PLOT SCALE

Generalized sensitivity indices
(Lamboni et al., 2011):

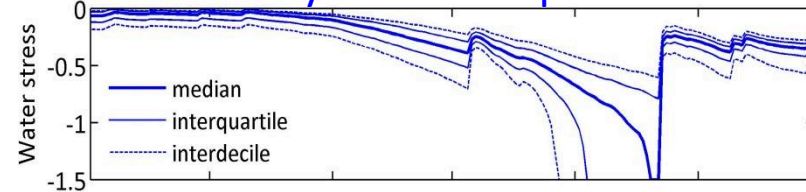
$$GS_i = \frac{\sum_d S_i(d) \cdot V(d)}{\sum_d V(d)}$$

$$GST_i = \frac{\sum_d ST_i(d) \cdot V(d)}{\sum_d V(d)}$$

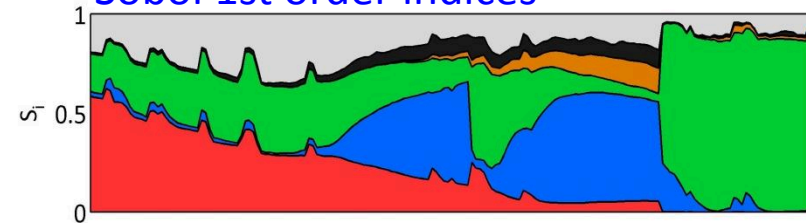
Parameter ranking



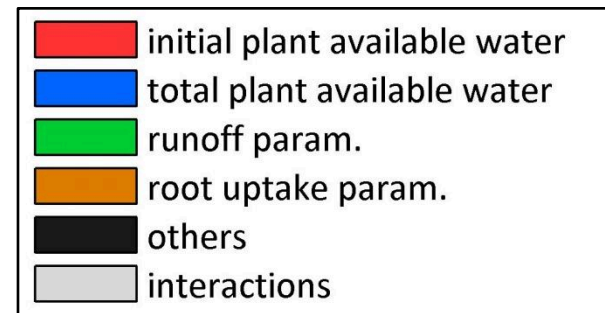
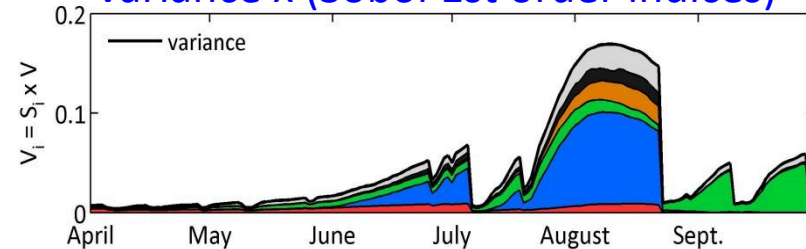
Uncertainty on the output



Sobol 1st order indices



Variance x (Sobol 1st order indices)



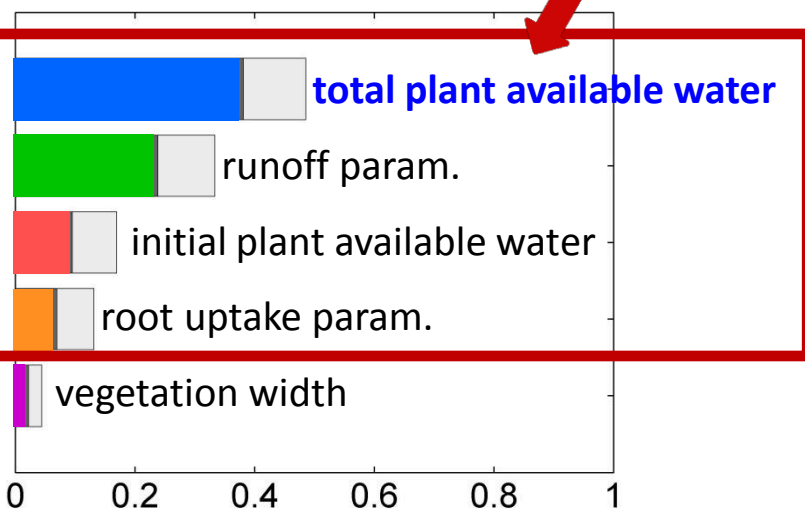
SA AT THE VINE-PLOT SCALE

Generalized sensitivity indices
(Lamboni et al., 2011):

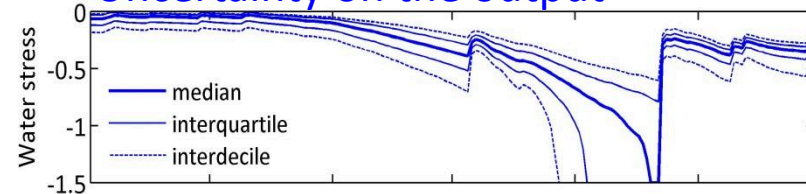
$$GS_i = \frac{\sum_d S_i(d) \cdot V(d)}{\sum_d V(d)}$$

$$GST_i = \frac{\sum_d ST_i(d) \cdot V(d)}{\sum_d V(d)}$$

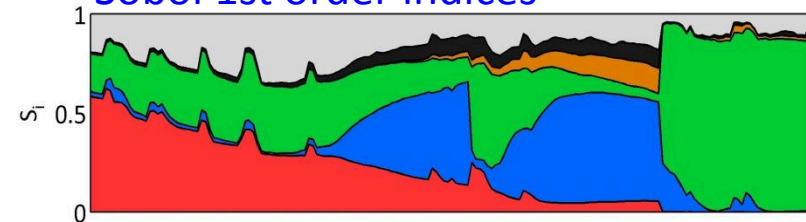
Parameter ranking



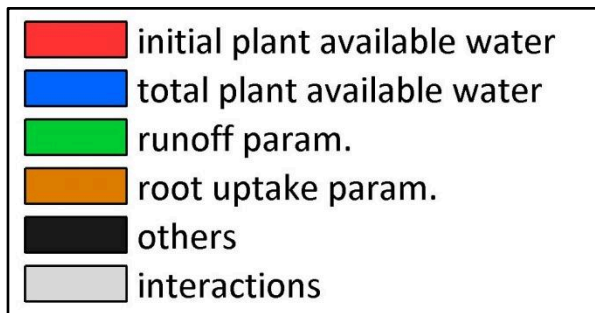
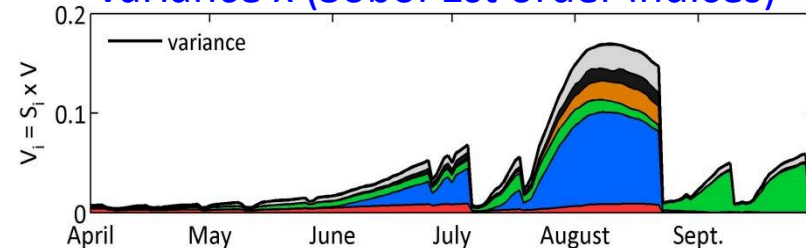
Uncertainty on the output



Sobol 1st order indices



Variance x (Sobol 1st order indices)



CONCLUSION

- ➔ SA via Sobol method of a agro-climatic model for the water management of vineyard
- ➔ Time-dependent inputs: individual influence of the weather components?
- ➔ Time-dependent output:
 - graphical presentation?
 - generalized sensitivity indices?



SA OF THE IRRIGATION TRIGGERING DATE

What if no irrigation is triggered?

- ➔ Irrigation date = last simulation day?
- ~~➔ Irrigation date~~ ➔ irrigation amount
- ➔ Irrigation NOT triggered in < 5% situations:
Uncertainty computed for the remaining situations

