Using ensemble weather forecasts in agronomy modelling

Ivana ALEKSOVSKA

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Contribution : L. RAYNAUD (Météo-France), R.FAIVRE (INRA), F. BRUN (ACTA) , M. RAYNAL (IFV), O. DEUDON (Arvalis), F. SOUVERAIN (Météo-France)

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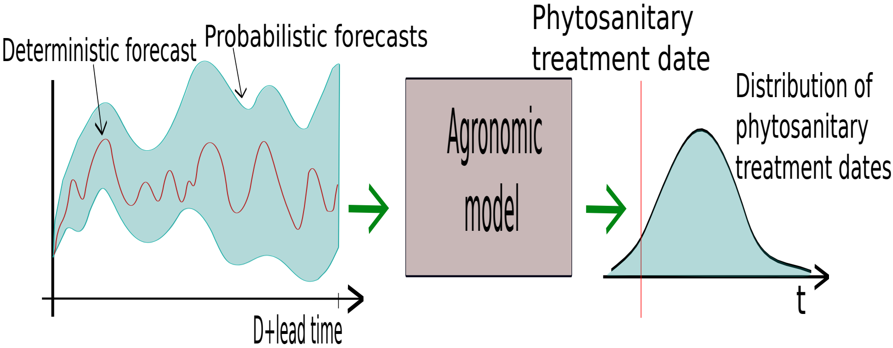
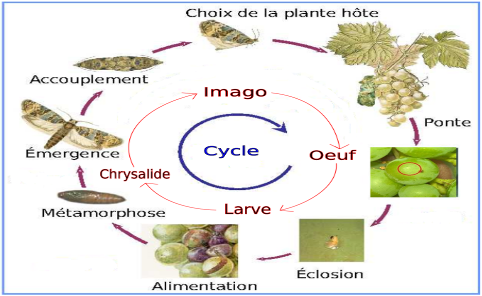
Introduction



1 : What is the influence of weather forecasts and their associated uncertainty on agronomy outputs ?

2 : How to chose/combine the appropriate weather forecasts in order to represent better the uncertainty in the outputs ?

Agronomic model : EVA



- Control of a **temperature** dependent pest : the worm of the vine grape [Chavent, 1983]
- Several reproductives cycles ;
- Four stages in one cycle: imagos, eggs, larvae, nymphs ;
- Optimal treatment : when the total population size of the eggs exceed a critical thresholds (2 and 15%).

Simulations with EVA

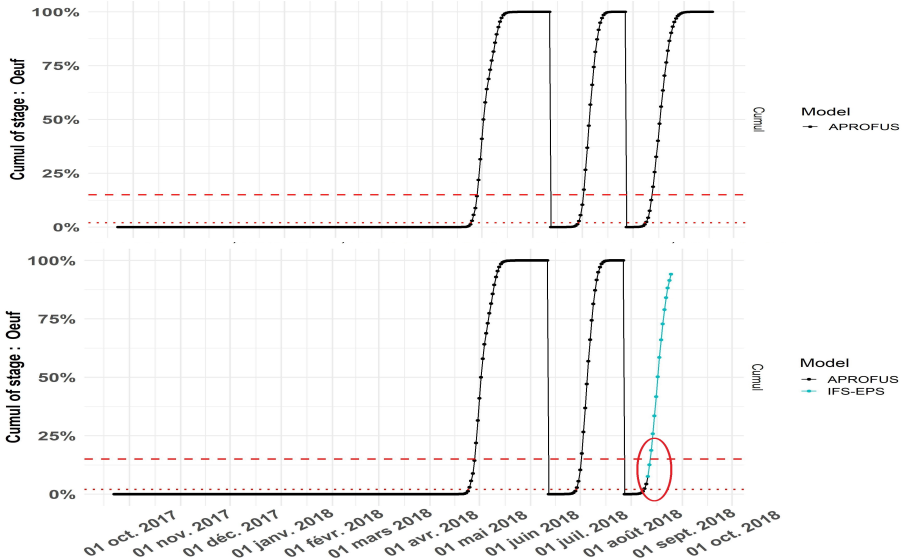
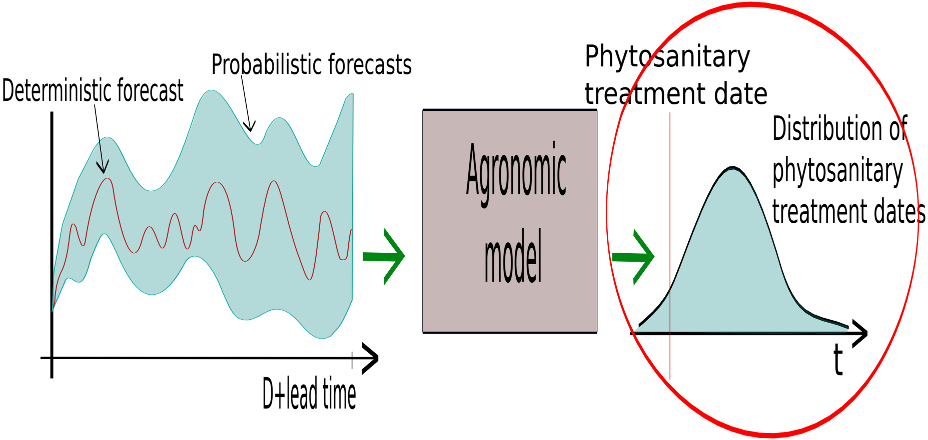


Figure: Dynamic evolution of cumulative stages eggs in Pic Saint Loup, associated to (up) observation and (down) observation coupled with forecast.

What is the influence of weather forecasts and their associated uncertainty on outputs ?



Probabilistic outputs of the EVA model

1. Example of EVA simulations using IFS-EPS (up to D+15).
2. Distribution of processing dates according to thresholds/decision/risk taking [Aleksovska et al., 2018] ;

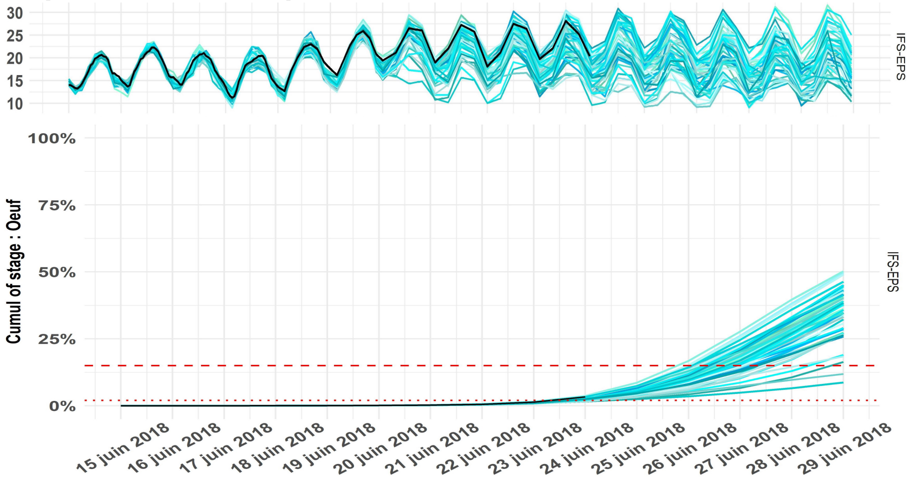


Figure: Up : Ensemble forecast of temperature, Down : Total population size of the egg stage, threshold of 2 % (dotted line) and 15 % (dashed line) in Turckheim.

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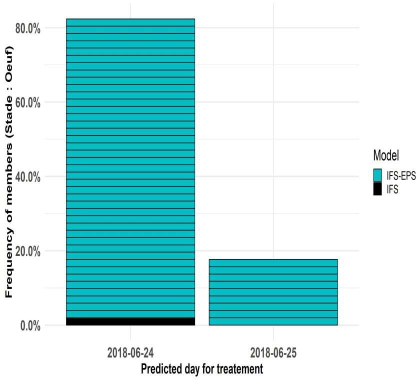


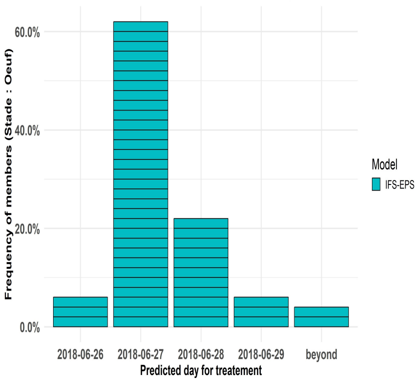
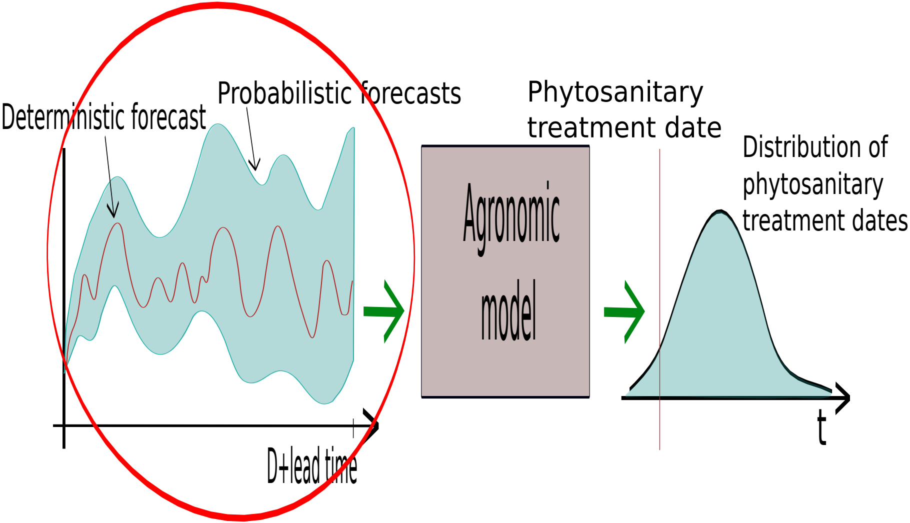


Figure: Histograms of treatment initiation dates with threshold, Left : 2 %. Right : 15 % in Turckheim.

How to chose/combine the appropriate weather forecasts in order to represent better the uncertainty in the outputs ?



What are the available sources of information ?

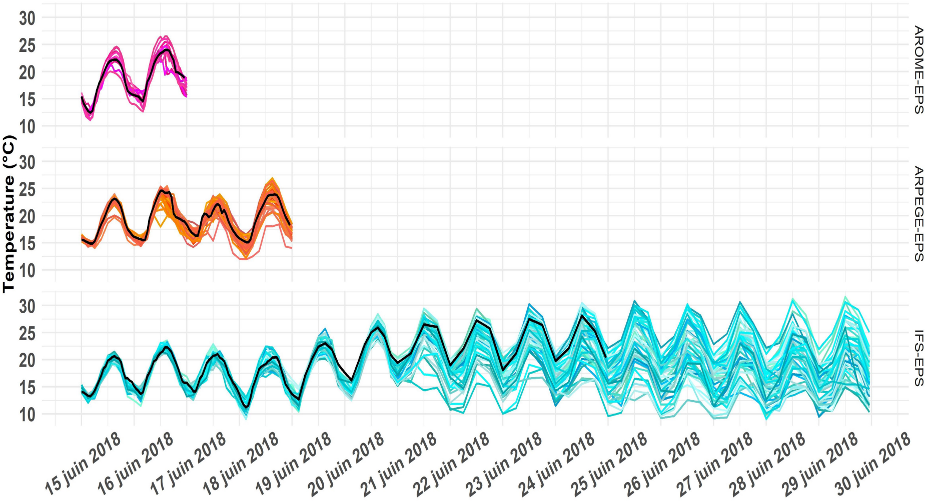


Figure: Ensemble forecast of the temperature and the deterministic forecast presented in black in Turckheim.

What are the available sources of information ?

AROME-EPS ; ARPÈGE-EPS ; IFS-EPS

Zone : France and neighbourhoods, Globe, Globe ;

Scenarios: 12, 35, 51 members ;

Horizontal resolution : 2,5 km, 10 km (France), 18 km ;

Lead-times : D+2, D+4, D+15/32 ;

Boundary conditions AROME-EPS: coupled with ARPÈGE-EPS.

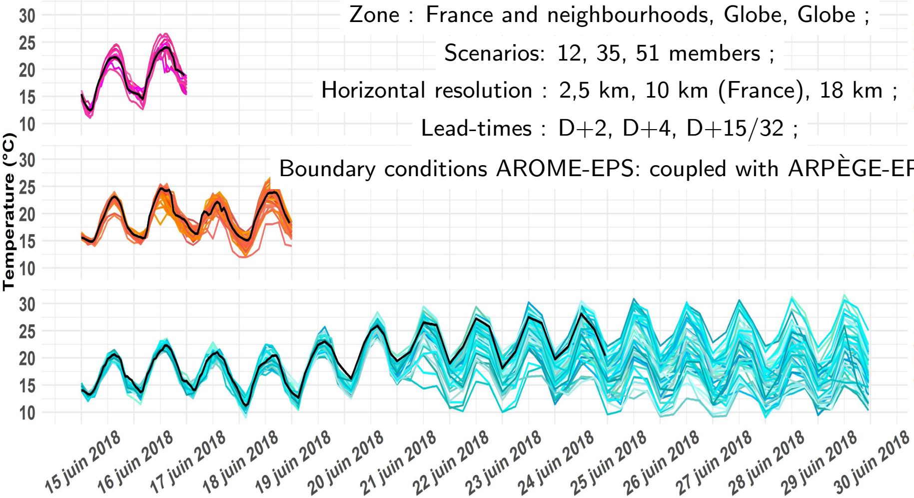
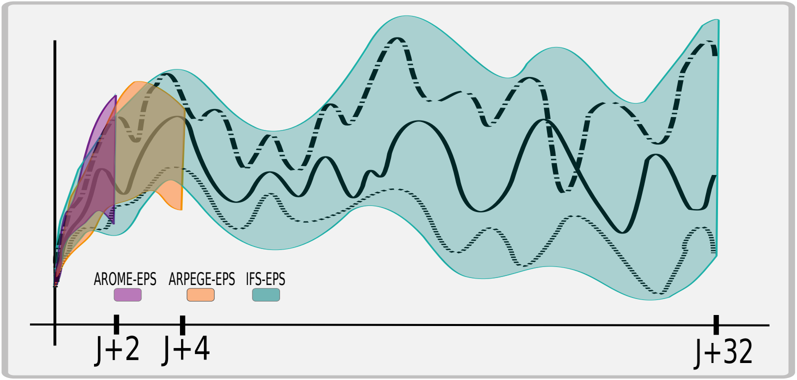


Figure: Ensemble forecast of the temperature and the deterministic forecast presented in black in Turckheim.

Research question

How to build a set of coherent scenarios from the various forecasting systems with different lead times ?



Consistent scenarios

Strategy : "Keep the highest resolution model for each forecast range"

1. Hypothesis :
   - D-D + 2 : AROME - EPS ;
   - D+2 - D+4 : ARPEGE - EPS ;
   - D+4 - D+15 : IFS - EPS.
2. Focus :
   - Connection between members as smooth as possible.
3. Strategy :
   - Based on analysis of the distance matrix between members ($W = 48h$) ;
   - Join with the closest member ;
   - Distance - Dynamic Time Warping (DTW) d_{DTW} [Berndt and Clifford, 1994].
4. Limitation :
   - The size of the final ensemble is limited (12 members) ;
   - Possible repetition of the closest member.

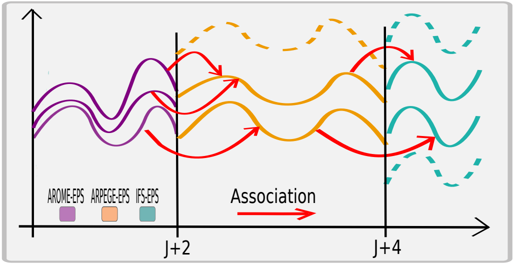


Figure: Methodology : Schematic representation

$$\mathrm{CS}_{\mathrm{m=(i,j,k)}}(t) = \begin{cases} \mathrm{ARO_i}(t) & \text{if } t \in [0h, 48h] \\ \mathrm{ARP_{j=j(i)}}(t) & \text{if } t \in [49h, 96h] \\ \mathrm{IFS_{k=k(j)}}(t) & \text{if } t > 96 \end{cases}$$

where $i = 1, \ldots, 12,\ j = 1, \ldots, 35,\ k = 0, \ldots, 50,$
$\mathrm{ARP_{j=j(i)}} = \min_j d_{\mathrm{DTW}}(\mathrm{ARO_i}(W), \mathrm{ARP_j}(W)),$
$\mathrm{IFS_{k=k(j)}} = \min_k d_{\mathrm{DTW}}(\mathrm{ARP_j}(W), \mathrm{IFS_k}(W))$

Post-processing

- Parametric methods : Non-homogenous Regression (NR) [Gneiting, 2014] ;
- Hypothesis : The predictive density of temperature is Gaussian [Gneiting et al., 2005]
- Unknown parameters : To be estimated using past forecasts and corresponding observations over a training period using Continous Ranked Probability Score (CRPS) [Gebetsberger et al., 2018] ;
- Procedure : Draw a discrete random sample of the same size as the raw set from the predictive distribution and reorganize all the sampled values according to the raw forecast to obtain the post-processed set using Ensemble Copula Coupling method (ECC) [Bremnes, 2007].

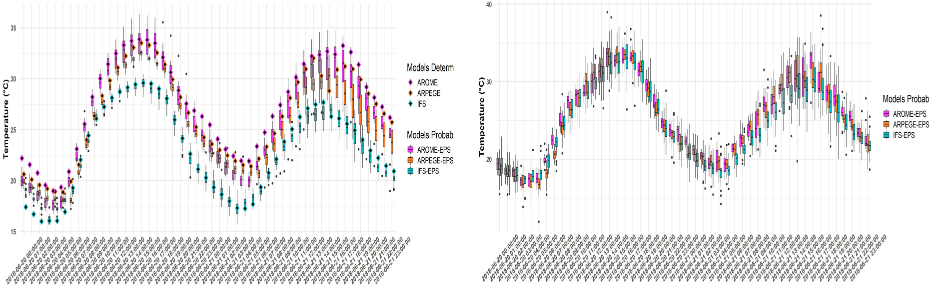
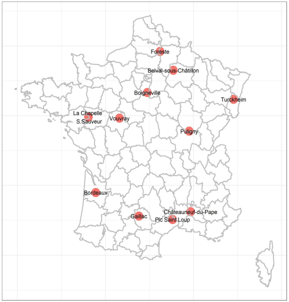


Figure: Box plots of temperature in Gaillac for the day's forecasts 2018/06/20 (left) raw forecasts, (right) post-processed forecasts.

Post-processing (BIAS and RMSE)



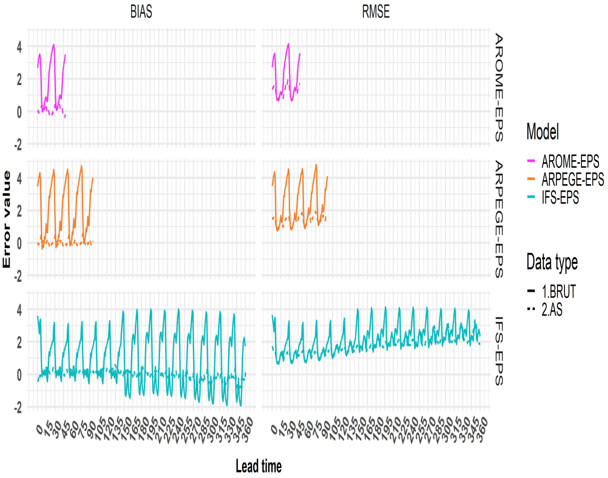


Figure: Left: France, Right: BIAS and RMSE during Summer (raw and post-processed forecasts) in Pic Saint-Loup.

Analysis of matrix of closest distances

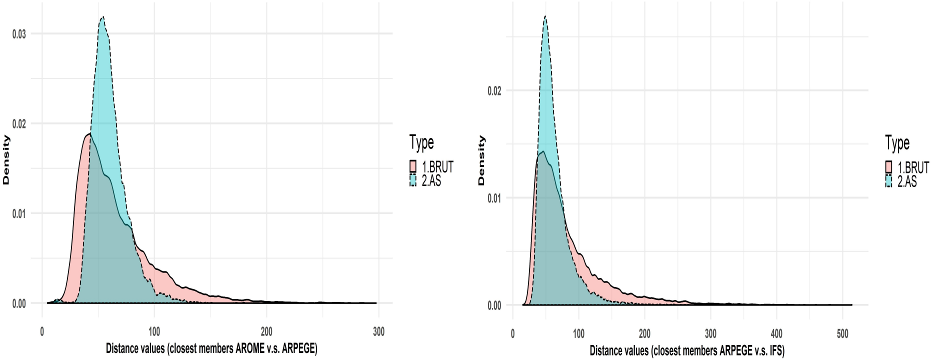


Figure: Distribution of closest distances during Summer 2018.

Keep the highest resolution model for each forecast range

- Matching with significant jumps at D+2 and D+4 in the case of raw forecasts and reduced jumps in the case of post-processed forecasts.

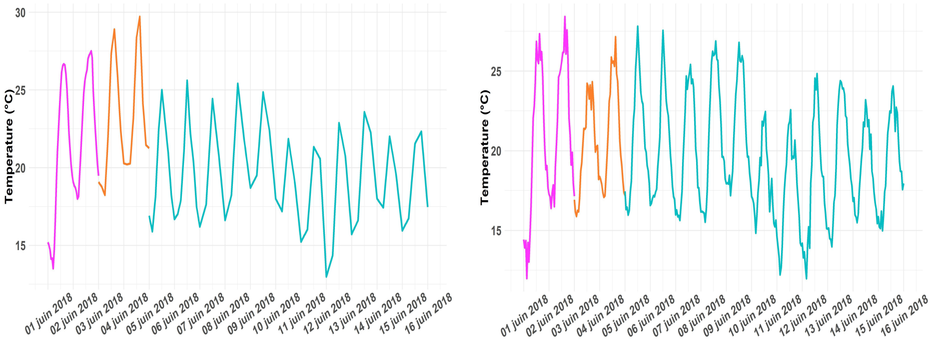


Figure: Coherent scenarios. Left: raw, Right: AS, in Chateaneuf-du-Pape.

Set of coherent raw scenarios

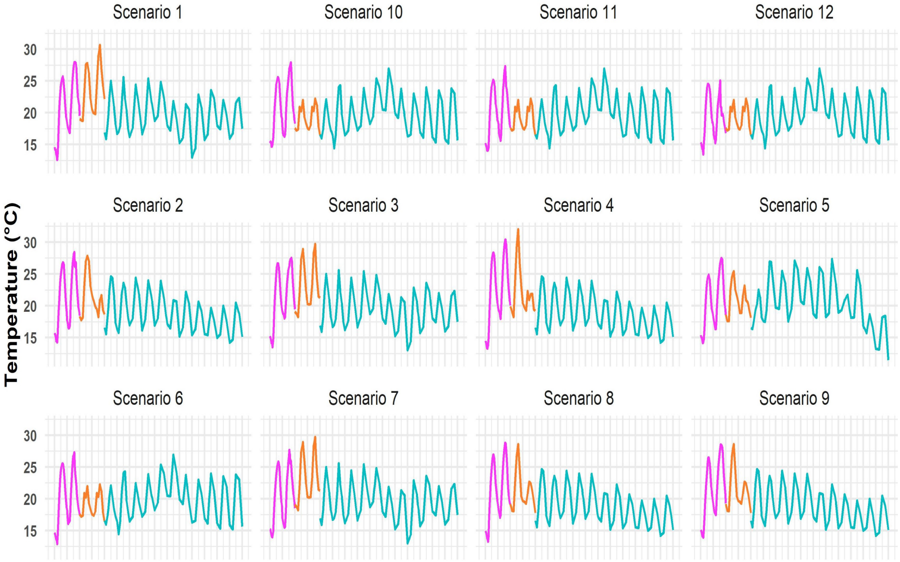


Figure: Set of coherent raw scenarios: 01/06/2018 in Chateauneuf-du-Pape

Set of coherent post-processed scenarios

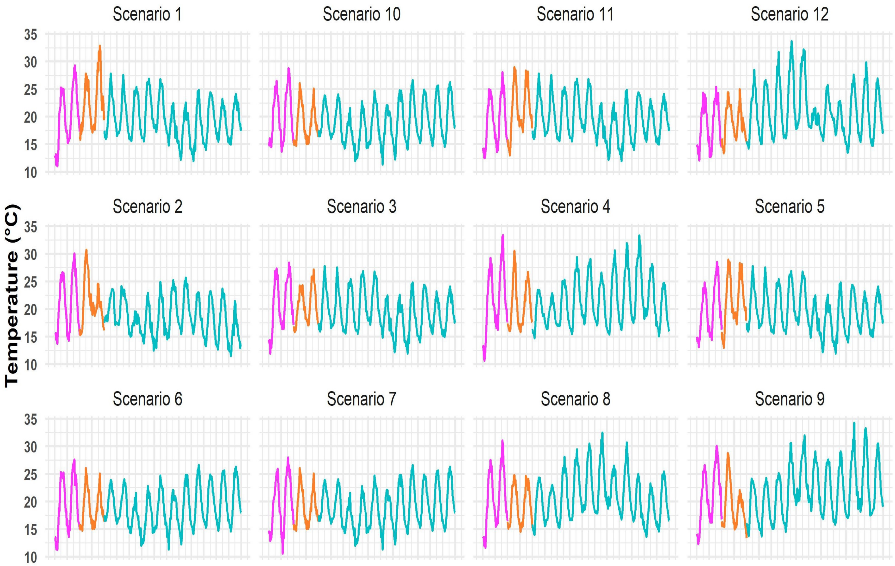


Figure: Sets of coherent post-processed scenarios: 01/06/2018 in Chateauneuf-du-Pape

Summary and Future work

- Summary
  - Meteorological inputs are important to agronomy model ;
  - First simulations from agronomy models using ensemble forecast ;
  - Uncertainty in forecast has an impact on agronomy models ;
  - Construction of coherent scenarios using ensemble forecast ;
  - First results based on distance ;

- Future work

  1 : Connection :
    - Analysis of gaps and repetition of members (work in progress);
    - Tuning the method (W=12h(24h), ECC_Q ...)
    - Other possible coupling methods (matching algorithmes).

  2 : Validation :
    - Validation of coherent scenarios (scores, agronomic simulations, etc.)
    - Extension to more than one weather variable (temerature, precipitation, ...)

  3 : Utilisation :
    - Appropriation by users.

Thank you for your attention !

ivana.aleksovska@meteo.fr