Assessing the impact of weather forecast uncertainties in crop water stress model predictions

Bachar Tarraf* François Brun Laure Raynaud Sébastien Roux

ACTA - The French Agricultural institutes

Centre national de recherches météorologiques (CNRM)

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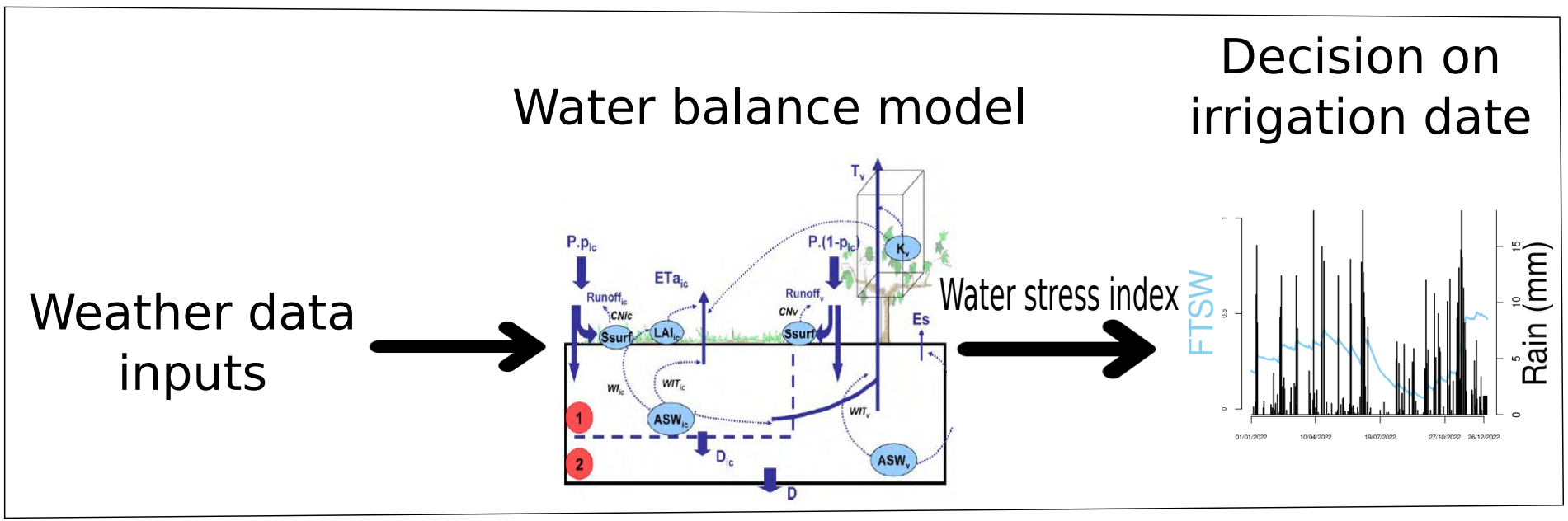
Objectives of the presentation

1. Show the advantage of using ensemble forecasts in irrigation Decision Support Tools (DSTs) in comparison with other used approach
2. Show how can we enhance ensemble predictions ? (Post-processing)
3. Discuss other possible sources of prediction uncertainties and quantifying it (sensitivity analysis)

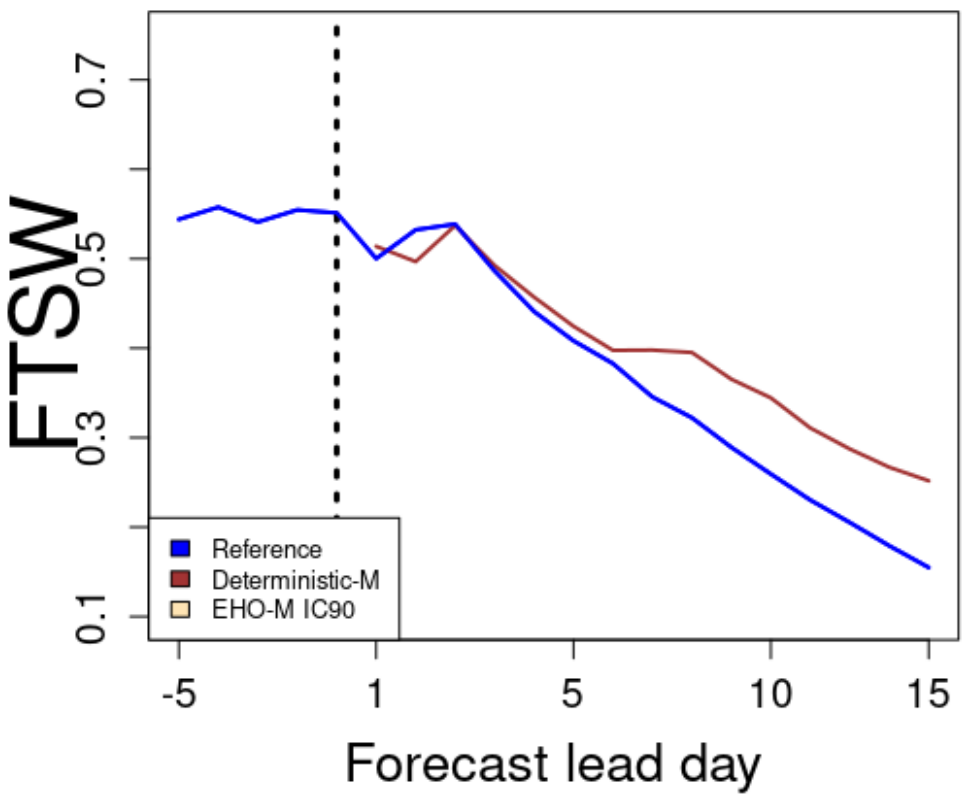
Context: Irrigation management using decision support tools (DSTs)

- Crop water stress DSTs are real-time models that compute a water stress index of the crop using weather data.



State of the art in the usage of irrigation DSTs

- **Without uncertainty information**: based on deterministic weather forecasts (i.e single value weather forecast)
- **With uncertainty information**: using ensemble of historical weather data (accounts for uncertainty but has drawbacks).



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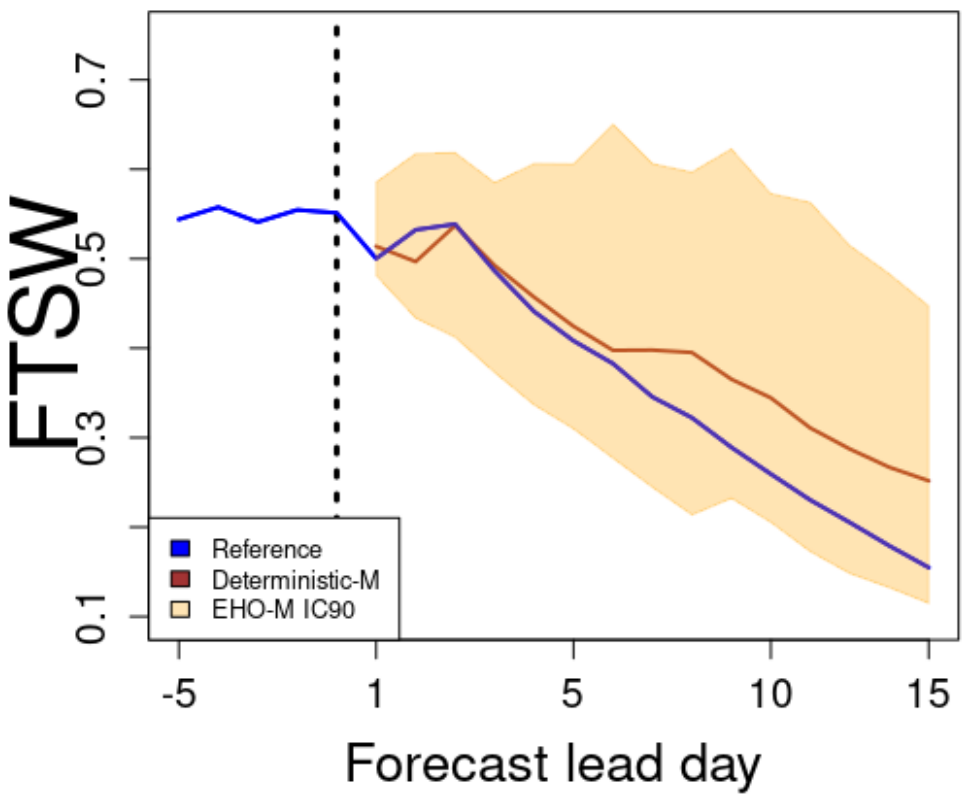
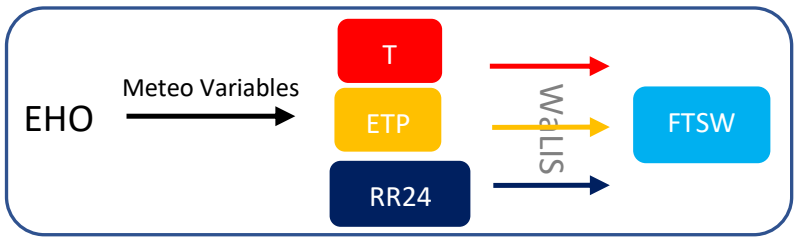


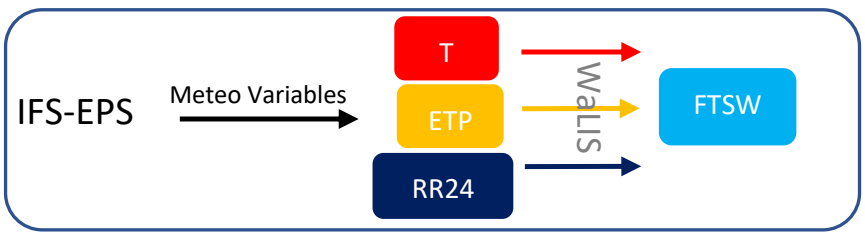
Objective 1: Advantage of using ensemble predictions

- Introduce the use of ensemble prevision (IFS-EPS) in irrigation DSTs and compare its perfromance to ensemble of historical observations (EHO)

Approach EHO-M



Approach EPS-M



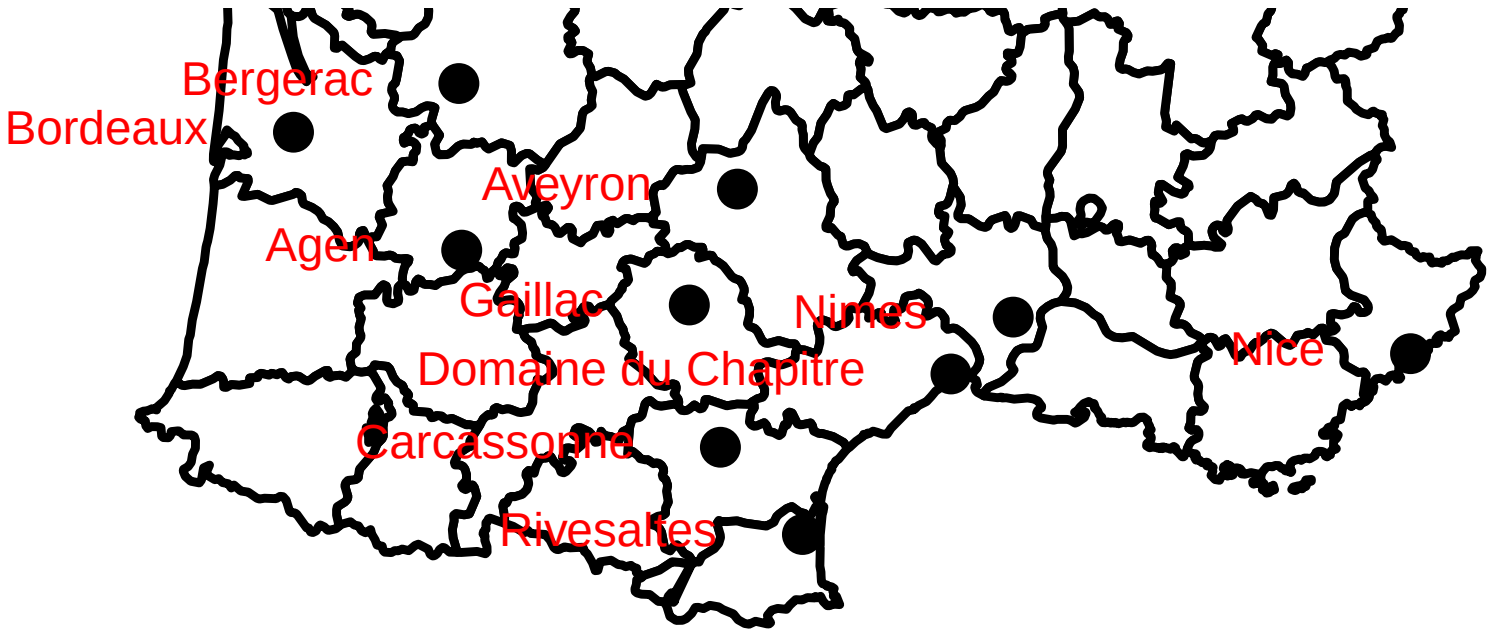
Uncorrected water stress index ensemble

Ensemble of daily mean temperature

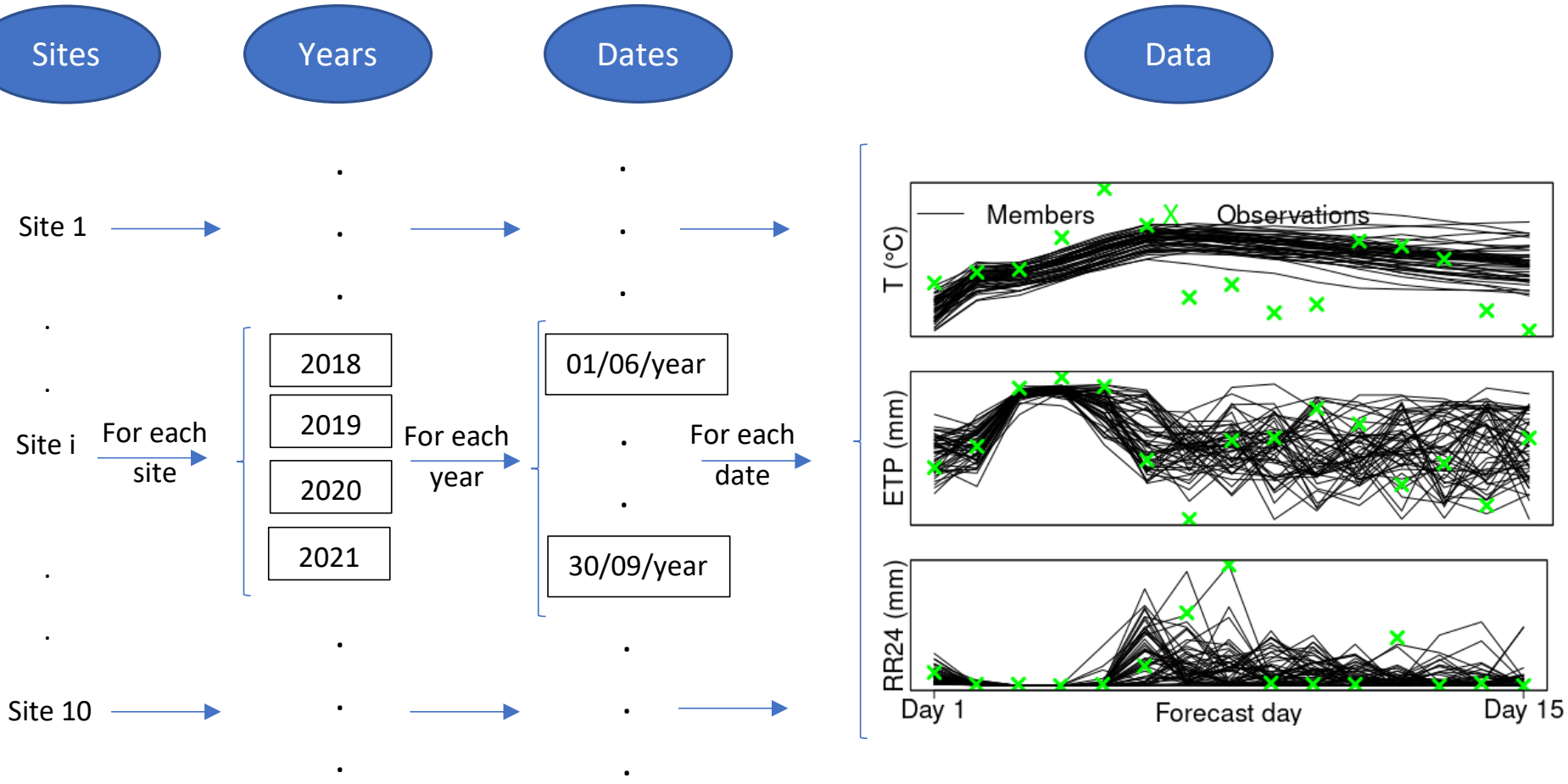
Ensemble of daily total evapotranspiration

Materials

- Numerical weather predictions used is **IFS-EPS** (zone: World, validity period: 15 days, size: 51 members, horizontal resolution: 18Km, initialization: 00:00 UTC)
- Ensemble of historical weather observation used: 12 years of prior observations for the desired period
- WaLIS water balance model (developed by Inrae and IFV) for vines irrigation
- Summer period (June to September), years 2018-2019-2020-2021
- 10 sites in the **south of France**

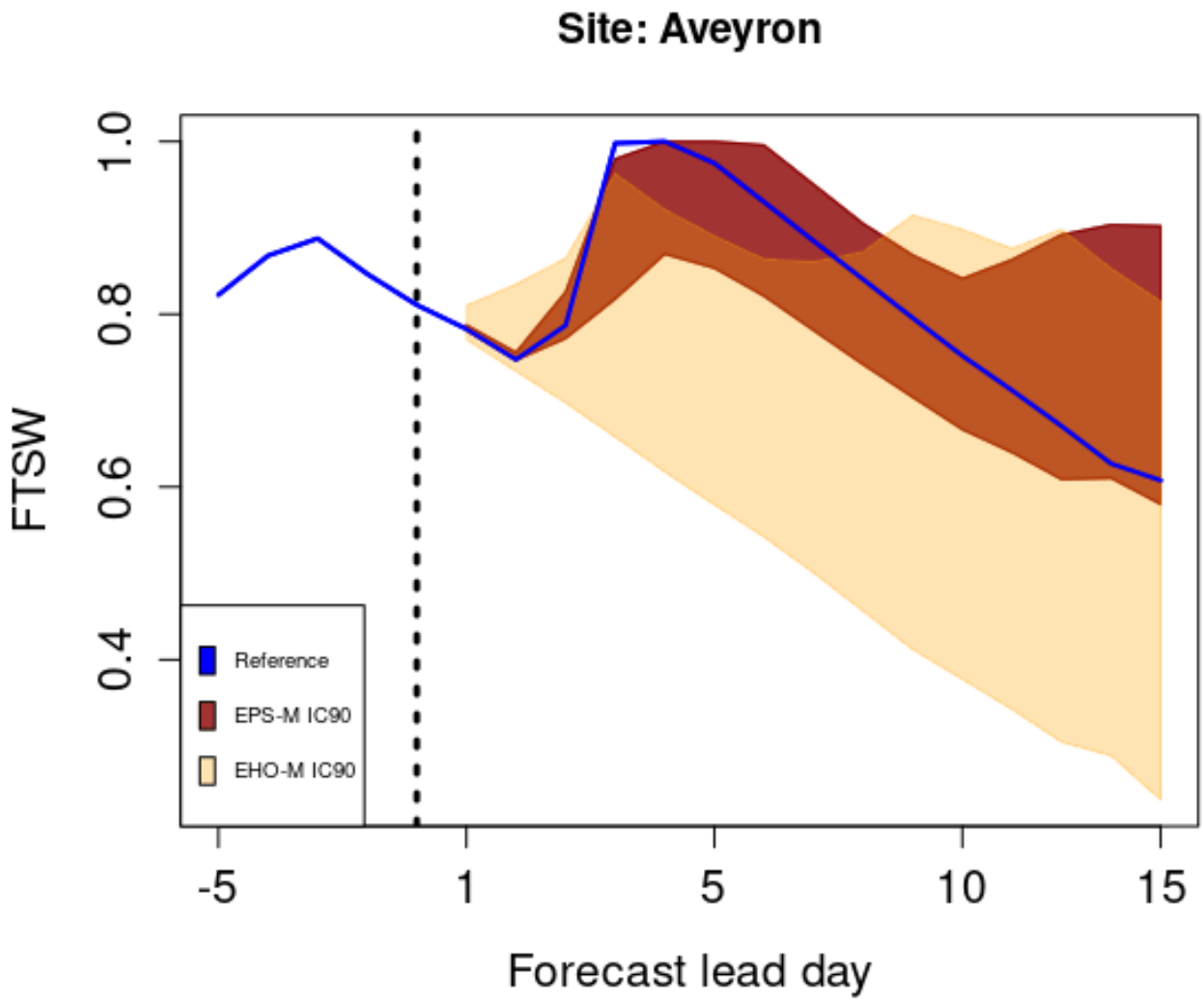


Materials: Weather Data Base



- Same for EHO but with 12 member ensemble consisted of the observation of the 12 previous years

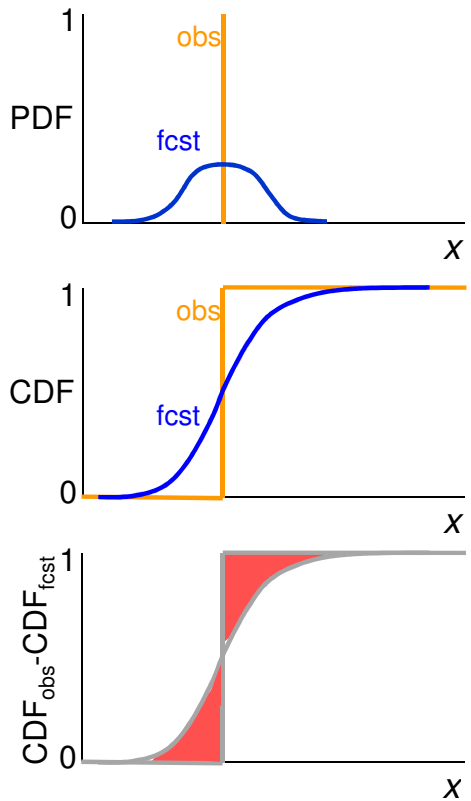
Results: comparison approach EHO-M vs approach IFS-EPS-M (particular case)



How to evaluate the performance of an ensemble prevision ?

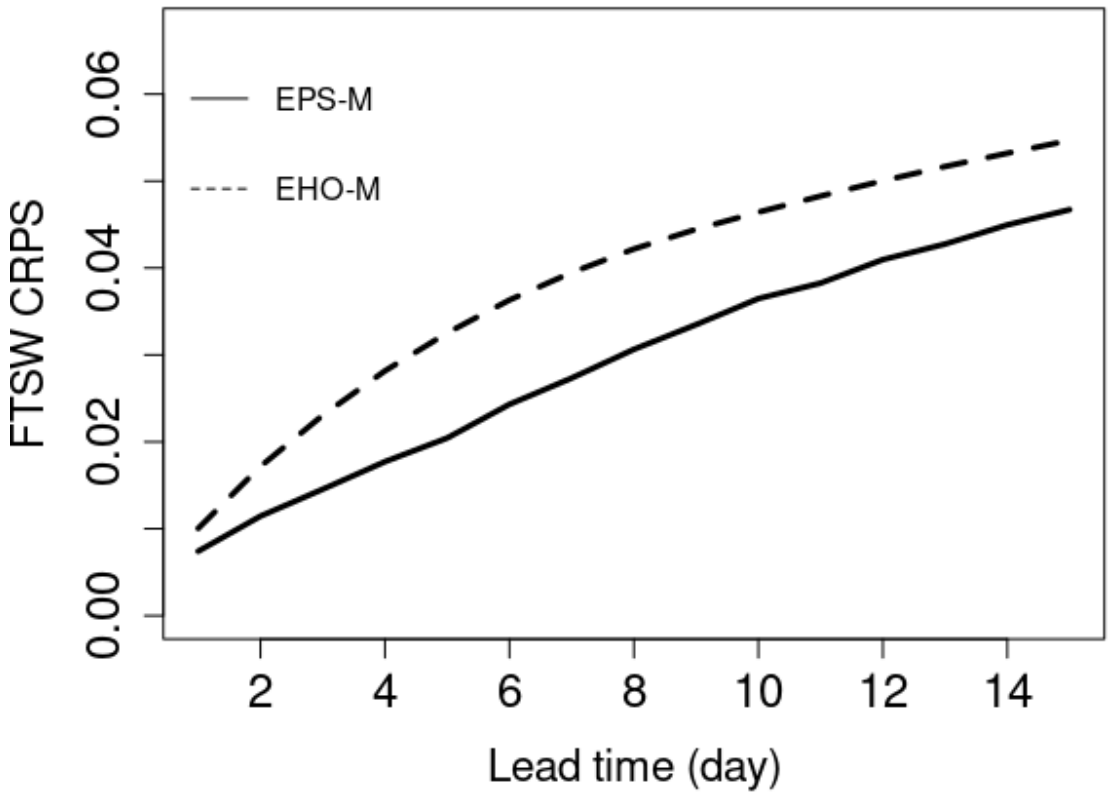
Many characteristics: Accuracy, reliability, sharpness etc ..
Scores: many scores ! In this study we use the continuous ranked probability score (CRPS):

$$CRPS = \int_{-\infty}^{+\infty} \left(F_{\text{fcst}}(x) - F_{\text{obs}}(x)\right)^2 dx$$



N.B: In our case the obs is the stress index computed by running the DST using the observation of the meteo variables.

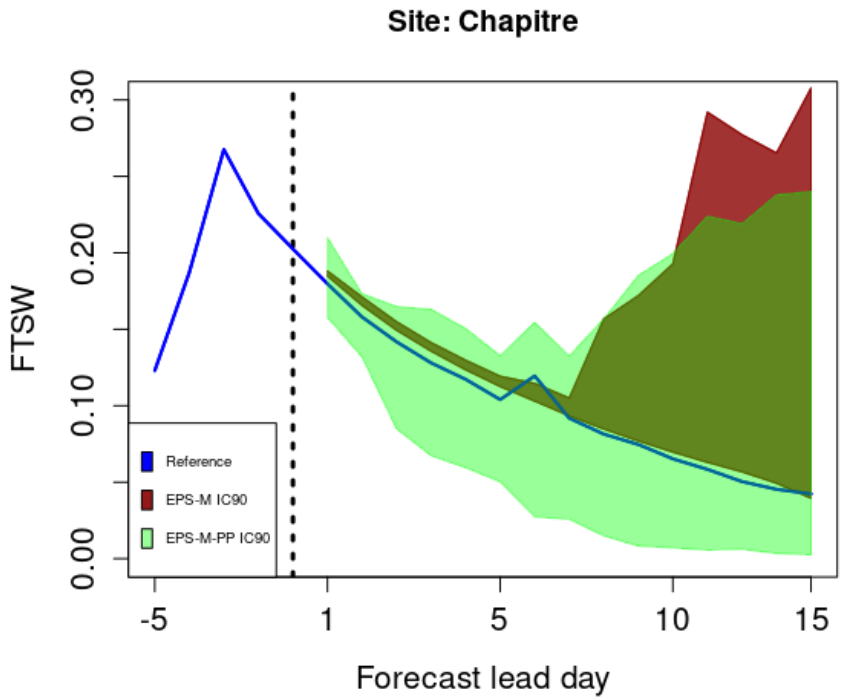
Results: comparison approach EHO-M vs approach IFS-EPS-M (Generalization)



Conclusion (objective 1): The use of ensemble prevision in irrigation DSTs has better performance in comparison with the use of historical weather observations.

Ensemble prediction are not perfect and need sometimes post-processing

- Existence of systematic bias error in the prediction sometimes
- Dispersion error in the ensemble sometimes

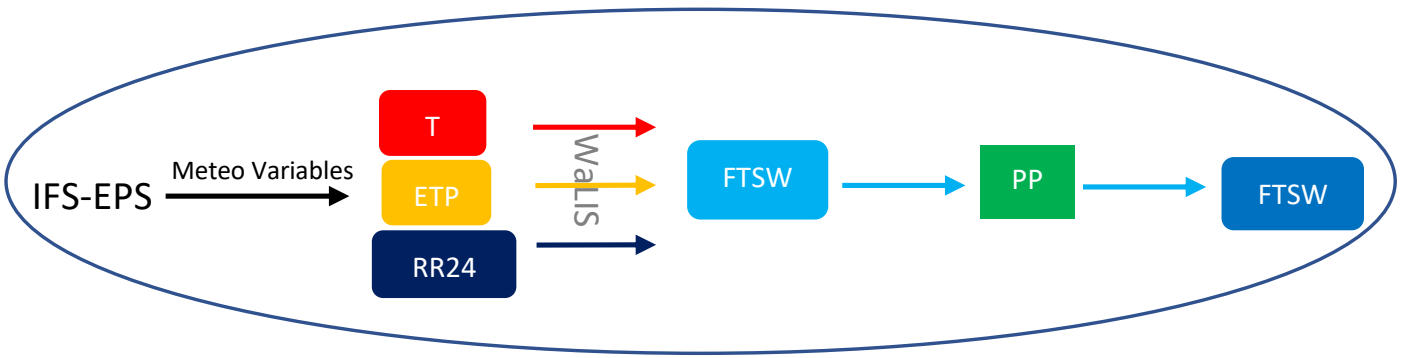


- Statistical post-processing methods to address these issues

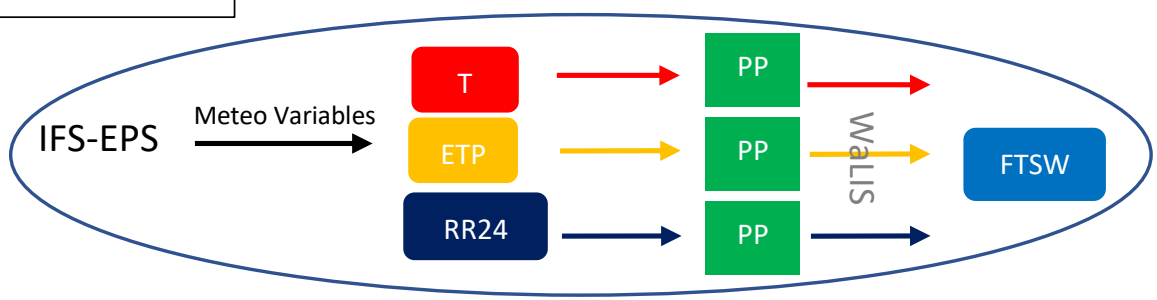
Objective 2: Enhance ensemble predictions using Post-Processing techniques

- Investigate the effect of two post-processing approaches (Approach IFS-EPS-M-PP vs Approach IFS-EPS-PP-M).

Approach EPS-M-PP



Approach EPS-PP-M



Ensemble of daily mean temperature

Ensemble of daily total evapotranspiration

Corrected water stress index ensemble

Ensemble statistical post-processing

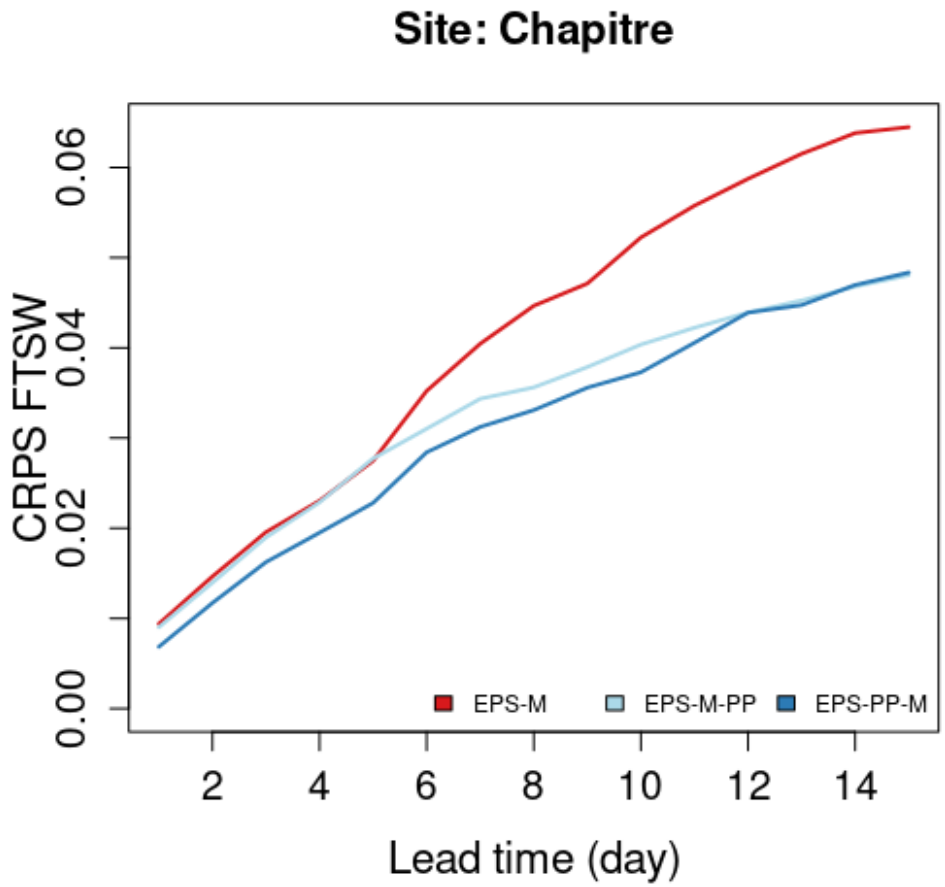
EMOS method for post-processing of ensemble prevision

Let $X_1, X_2, ..., X_N$ be the members of the ensemble X.

- Assumption on the distribution of the ensemble to post-treat (e.g normal distribution).
- Fit the parameters of predictive distribution $N(a + b\overline{X}, c + dV(X))$ by minimizing the CRPS on a training data set.
- Usually the training data set is a moving window consisting in T training days before the day J of the prevision to post-treat.

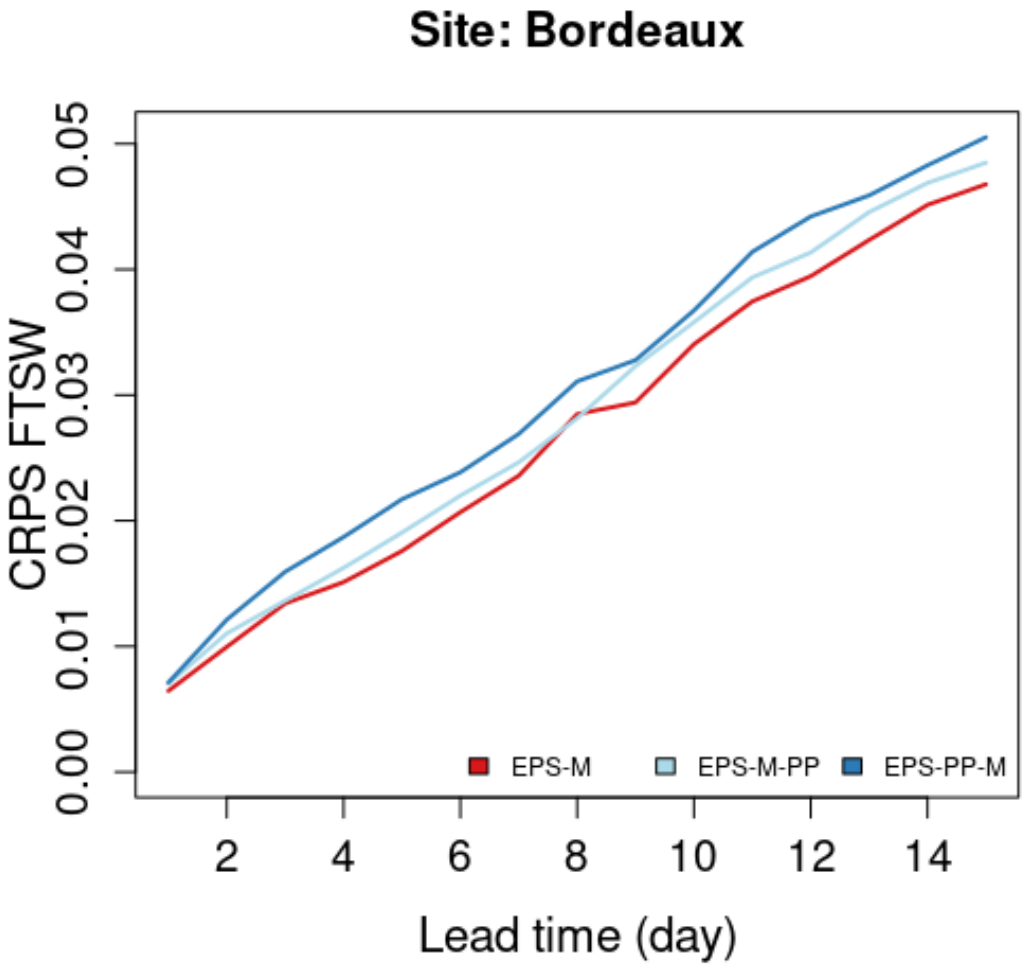
Results (Post-processing EMOS)

- 4 out of 10 tested sites shows improvement in CRPS after Post-Processing
- Improvement becomes significant starting lead ~ 5
- Generally, no significant difference between the two post-processing approaches



Results (Post-processing EMOS)

- 6 out of 10 tested sites: raw ensembles as good as or better than post-processed ones

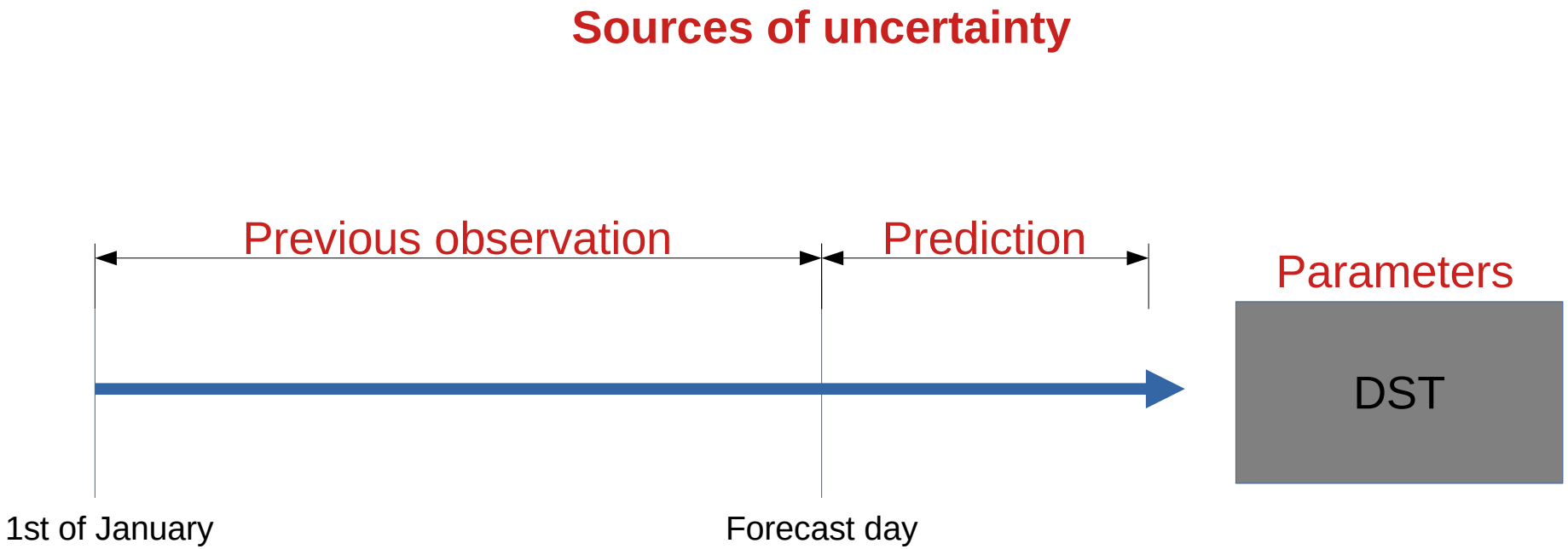


Conclusion (objective 2)

- Post-processing of ensemble water stress index could show improvement in ensemble previsions locally in some sites.
- Globally on all sites post-processing the water stress index ensemble prevision could improve the predictions by reducing the dispersion error and the bias.
- No advantage in post-processing directly the water stress index (more computationally expensive in operational use).

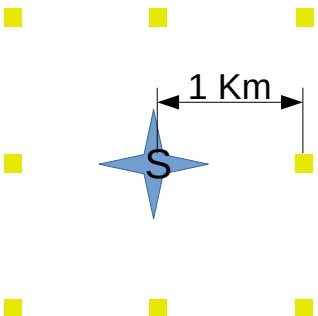
Perspectives (Objective 3):

- Evaluate and compare the different sources of uncertainty (DST Parameters vs Prior weather Observations vs Forecast).



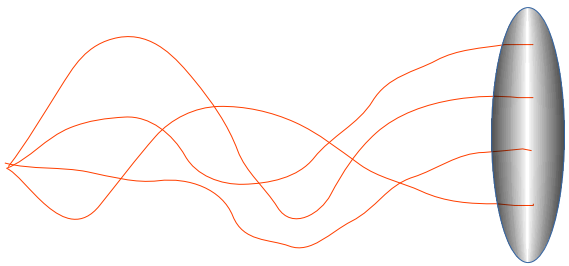
Perspectives (methods):

Uncertainty of previous observations



Obs data of the 8 neighbour stations

Uncertainty of prediction



Members of the ensemble prediction

Uncertainty of DST parameters

From literature or hypothesis

Perspectives (Preliminary results using Sobol indices):