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

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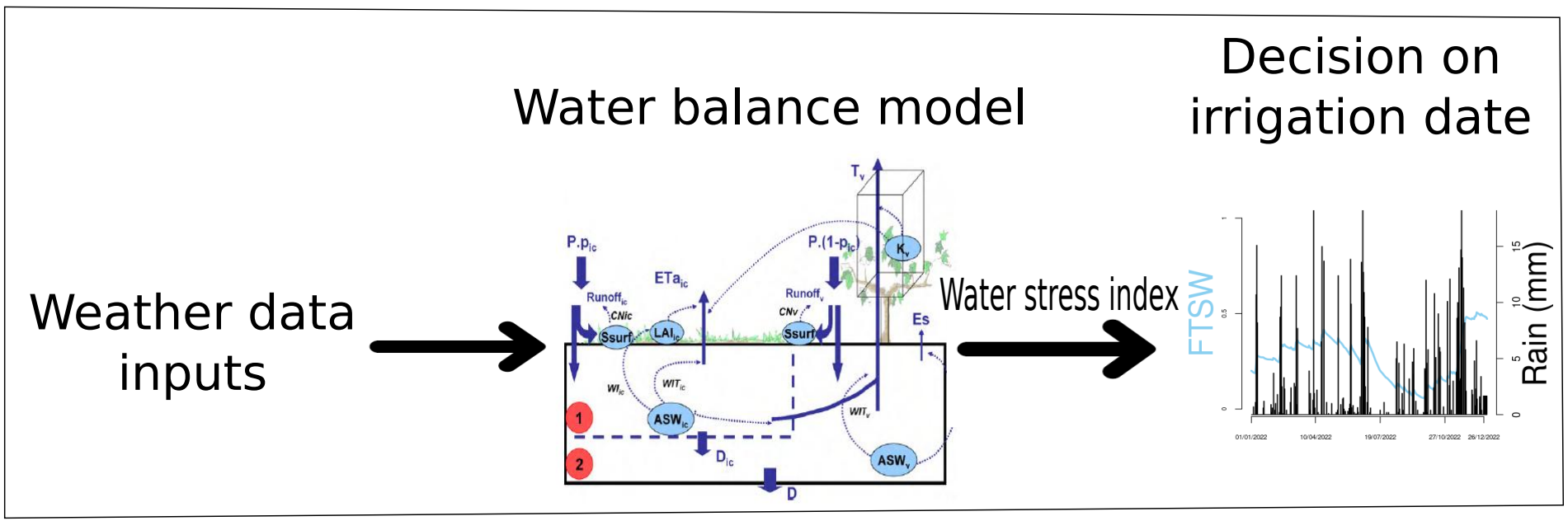
Context: Crop water stress and irrigation

- Agriculture accounts for 70% (ref. world bank) of all freshwater withdrawals globally
- Drought is more frequent due to global climate change
- $\Rightarrow$ Crop irrigation is more often a necessity
- The management of water use in irrigation is important

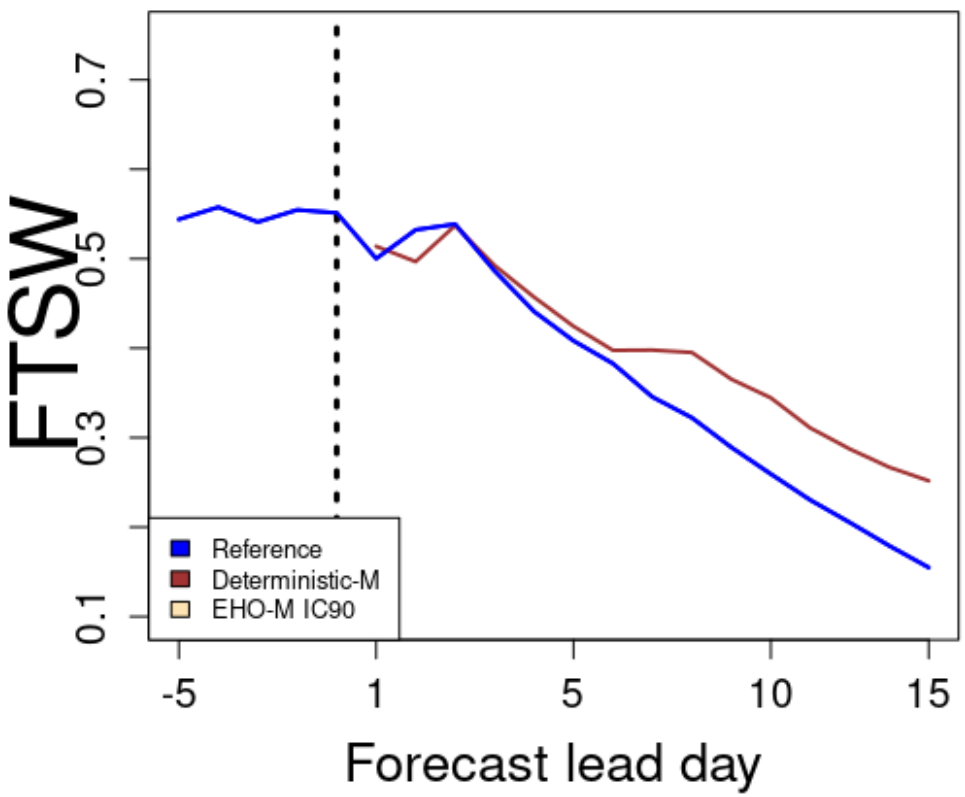
Context: Irrigation management using decision support tools (DSTs)

- 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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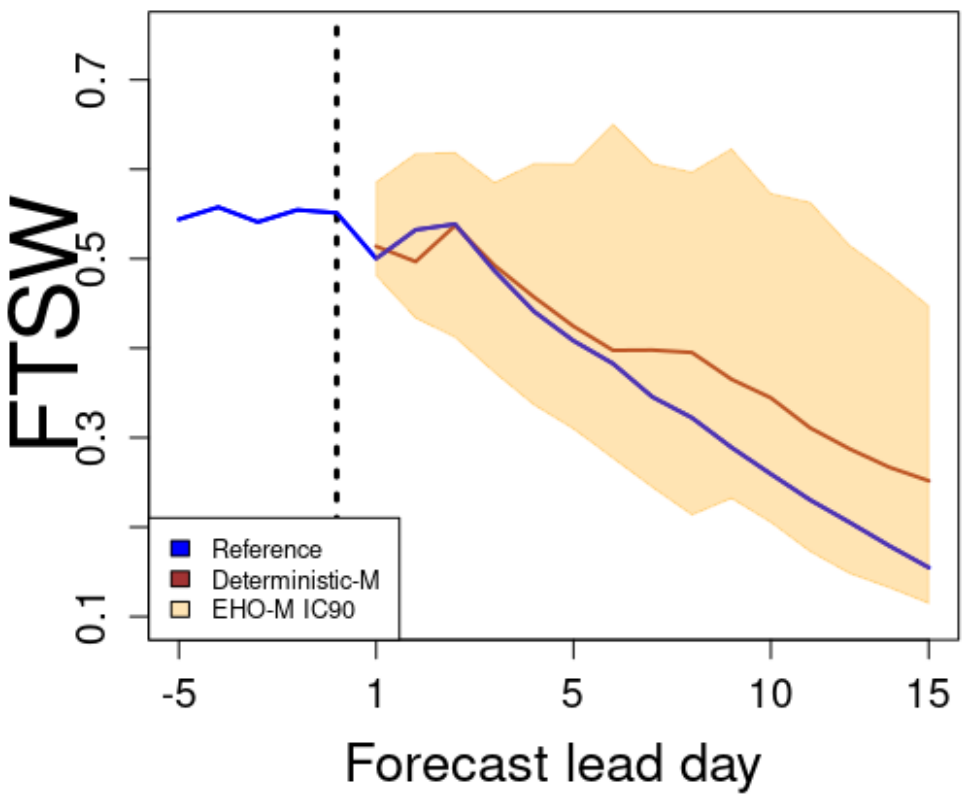
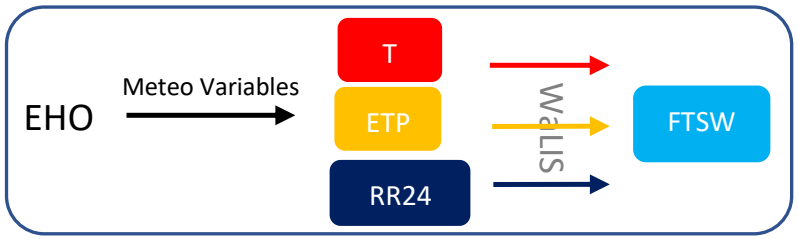


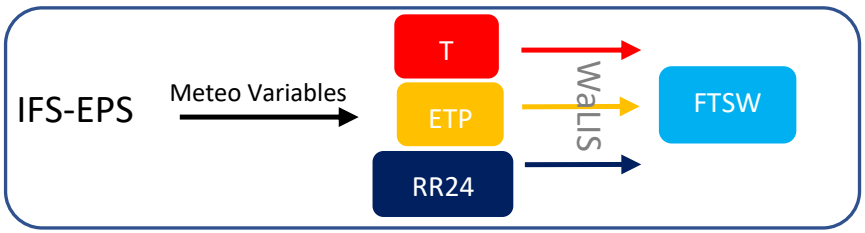
Objective 1 of the study

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

Approach EHO-M



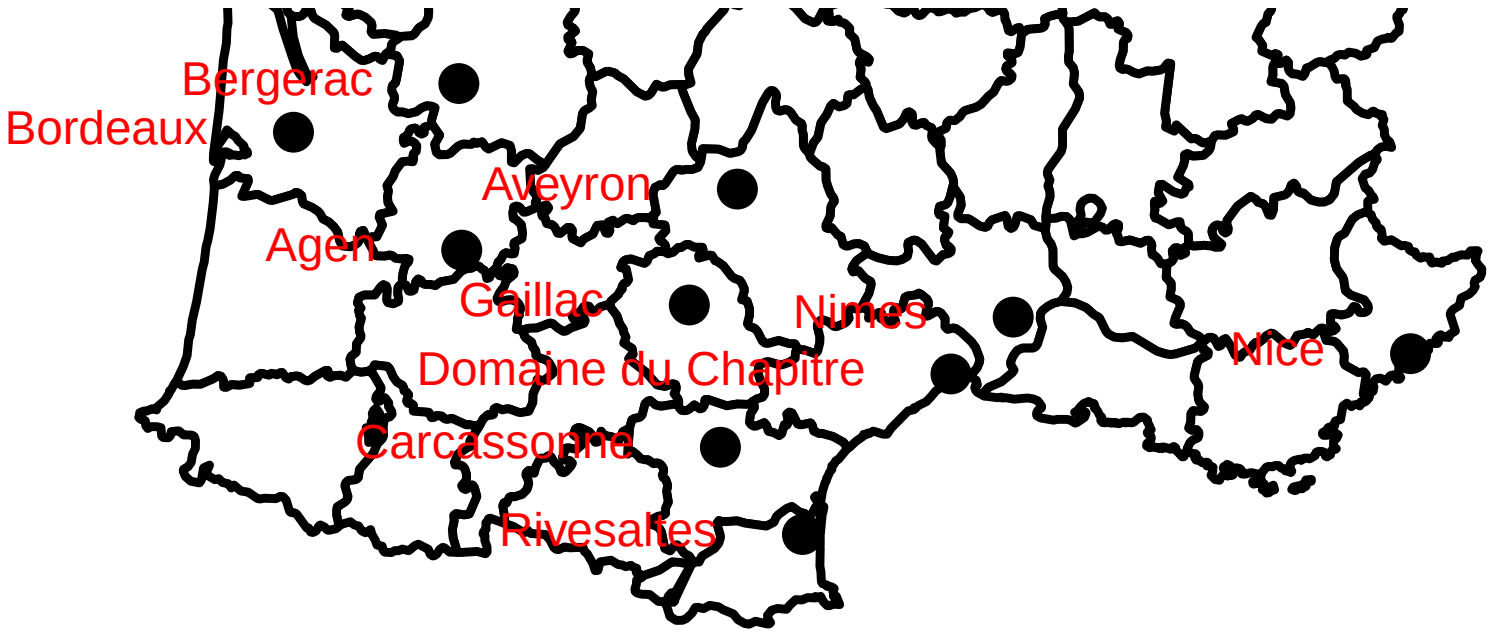
Approach EPS-M



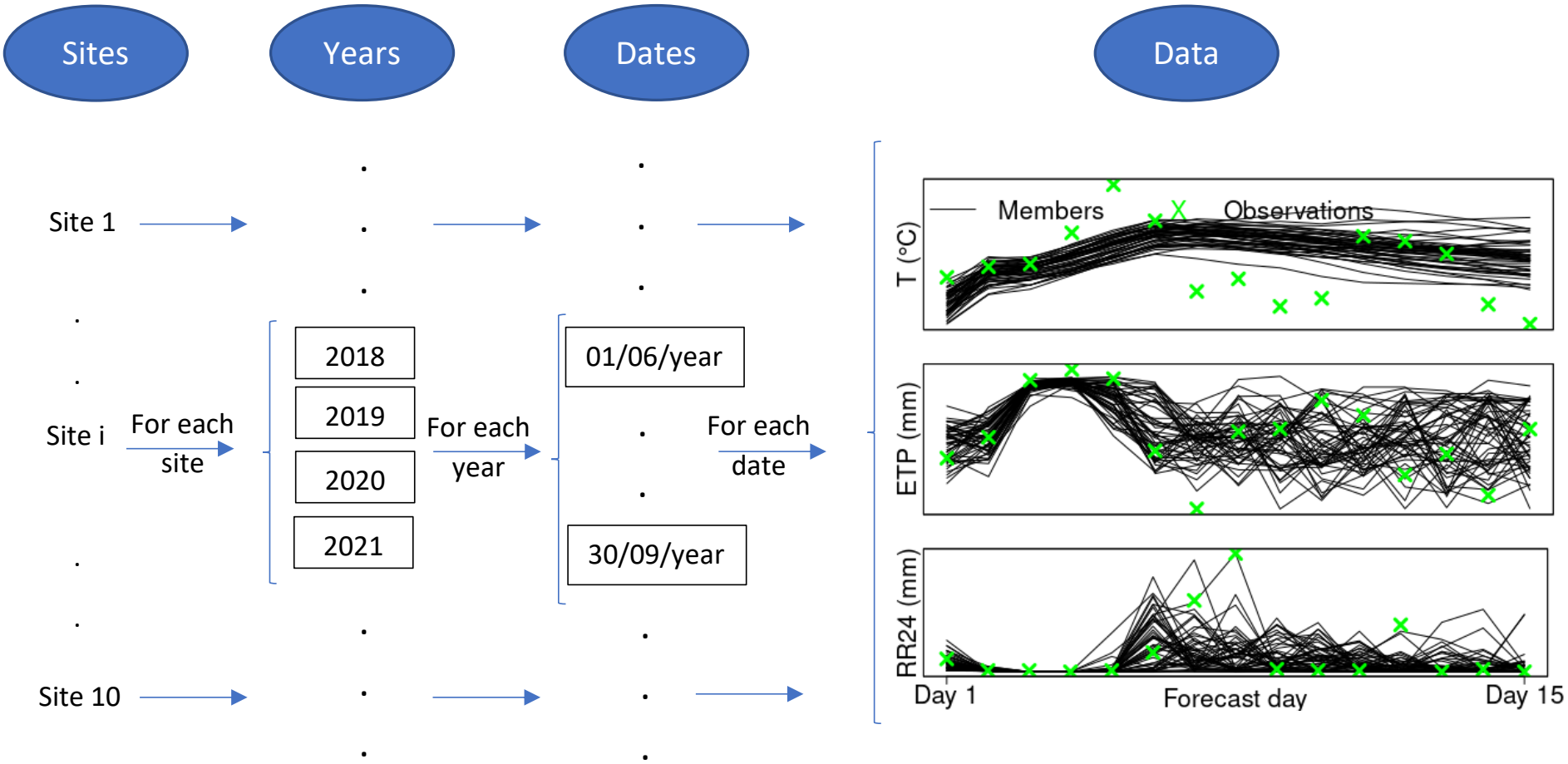
- Uncorrected water stress index ensemble
- Ensemble of daily mean temperature
- Ensemble of daily total evapotranspiration
- Ensemble of daily total precipitation

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**

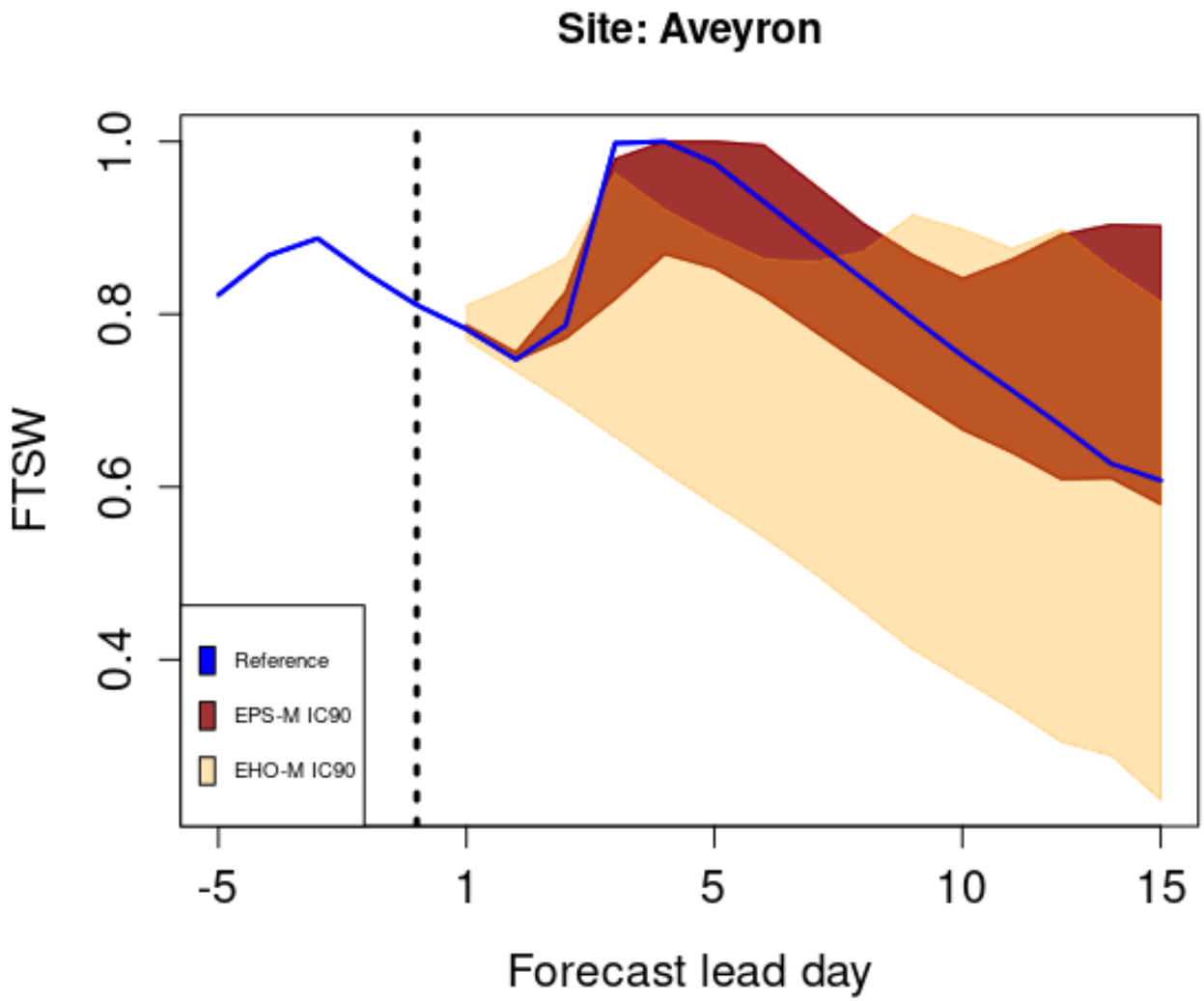


Materials: Weather Data Base

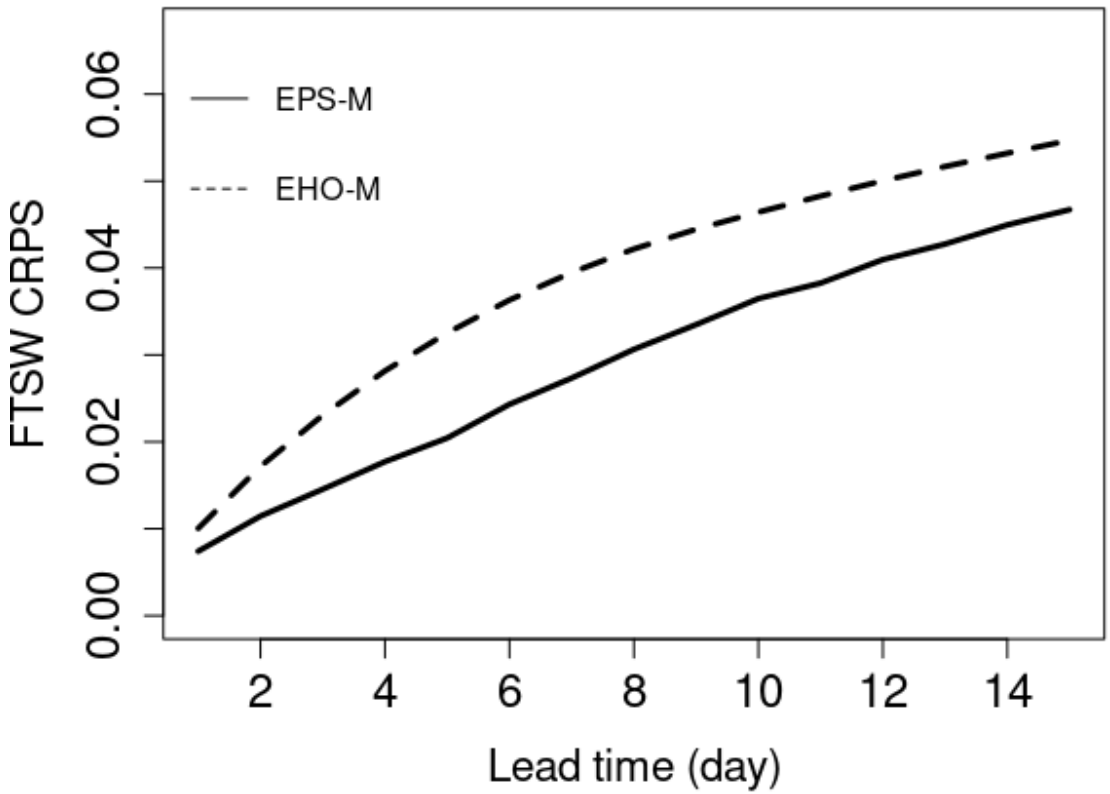


- Same for EHO but with 12 member ensemble consisted of the observation of the 12 previous years

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



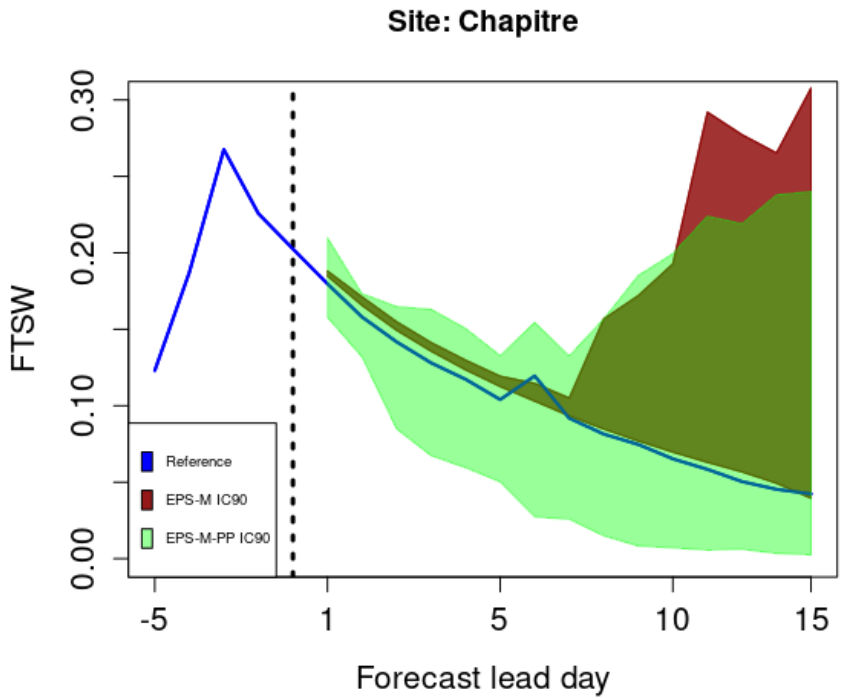
Results: comparison approach EHO-M vs approach IFS-EPS-M (Generalization)



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

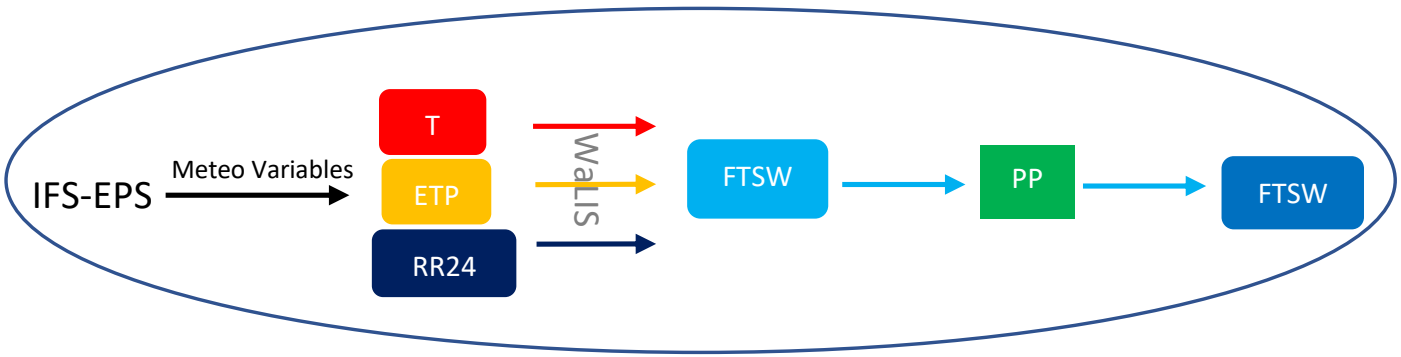


- Statistical post-processing methods to address these issues

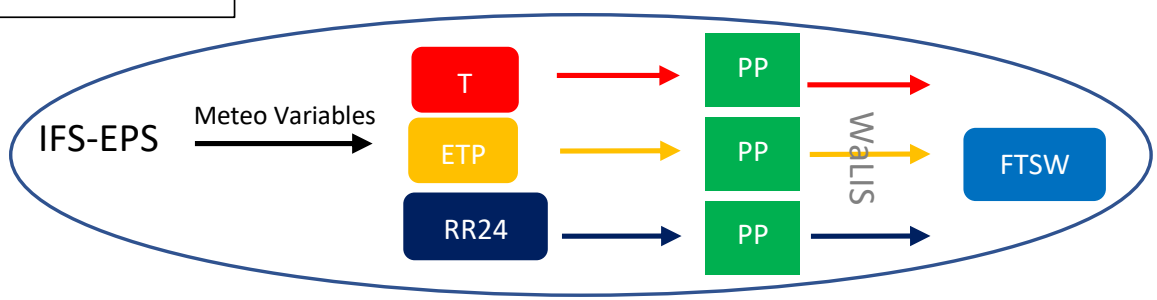
Objective 2 of the study

- 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
- Ensemble of daily total precipitation
- Corrected water stress index ensemble
- Ensemble statistical post-processing
- Uncorrected water stress index ensemble

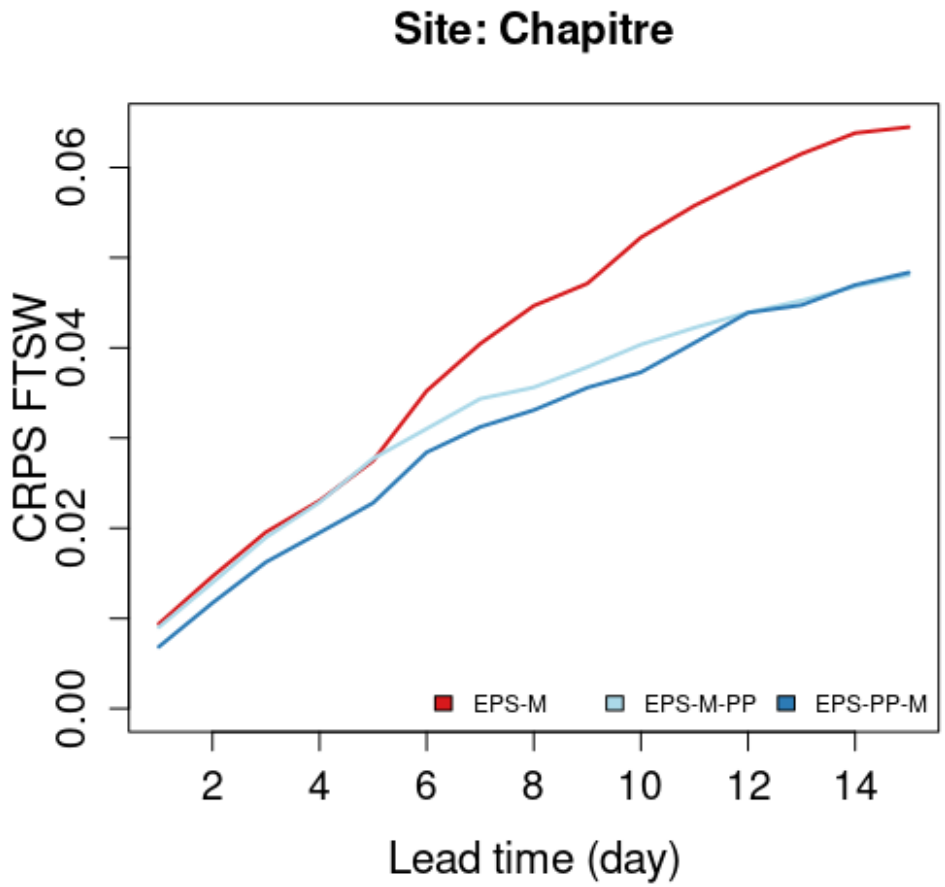
EMOS method for post-processing of ensemble prevision

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.

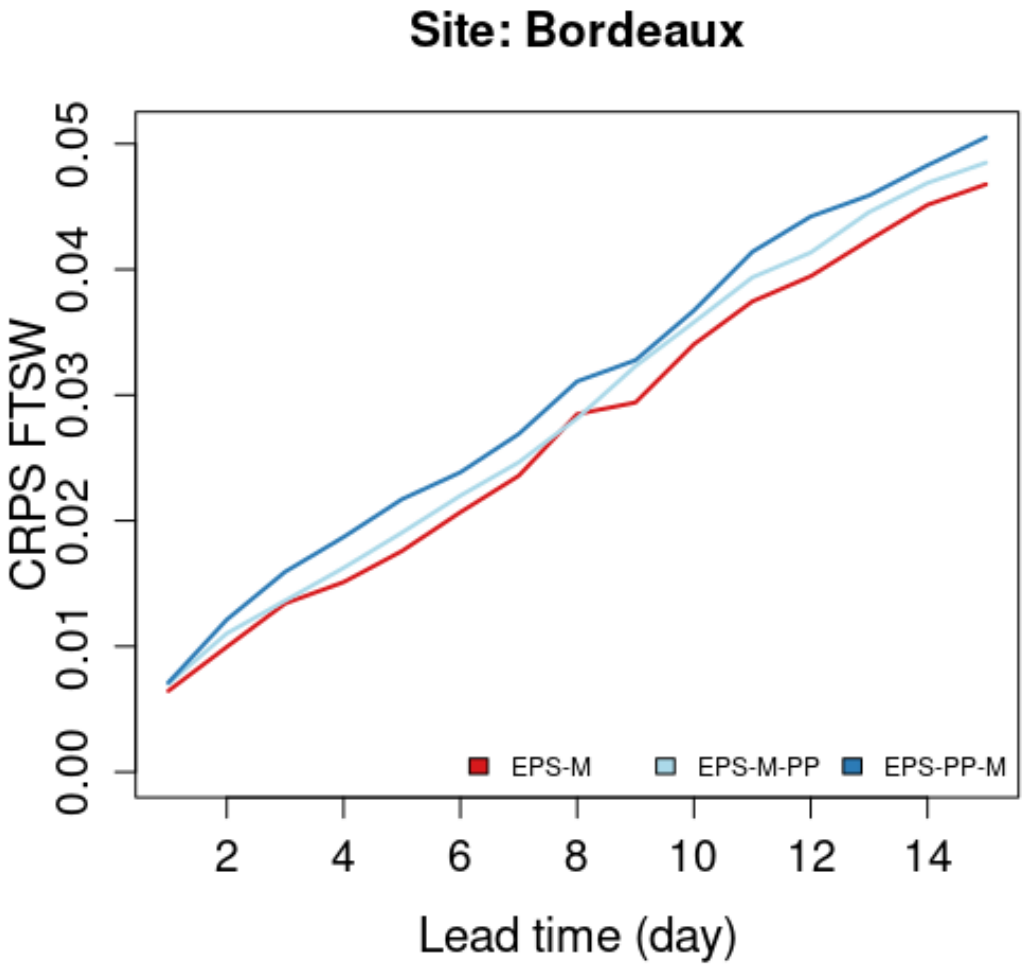
Results (Post-processing EMOS)

- 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).

Open question and Perspectives:

- Why in some situations the post-processing does not enhance the raw ensemble forecasts ?
- Evaluate and compare the different sources of uncertainty (DST Parameters vs Prior weather Observations vs Forecast).