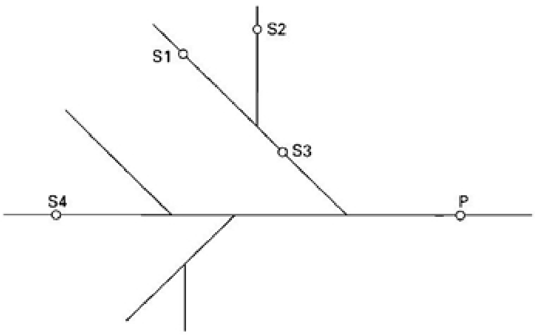
BAYESIAN DYNAMIC TEMPORAL PREDICTION

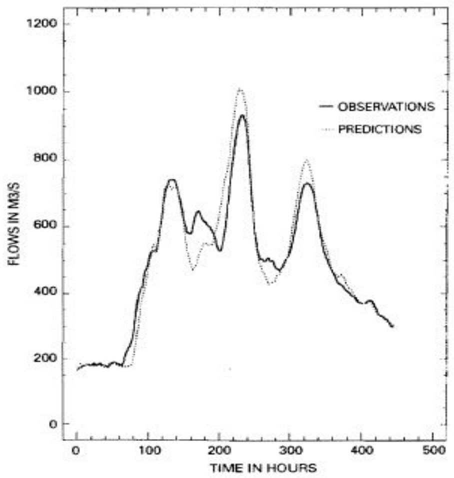
Description

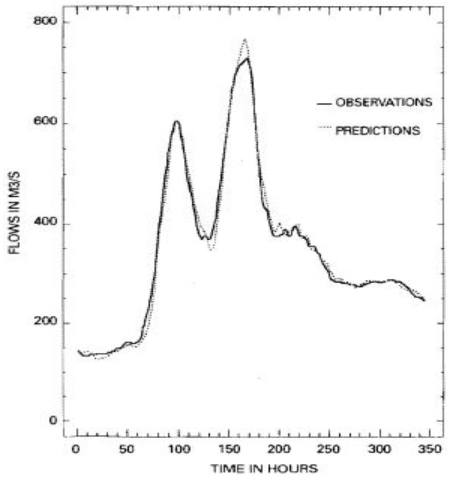
Our research group predicts at any time *t*, the flow of a unidimensional variable that will occur at *t+h*. It is also possible to predict what happened in previous moments, when *h* is negative. The dynamic Bayesian linear model is used for this purpose. This model has been successfully implemented for the prediction of flows at a point in successive instants of time when flow rates are known in several stations located upstream of the point. The model has been successfully applied to the prediction of floods, but can also be used for virtually any unidimensional dynamic situation, such as investment appraisal, electricity demand etc.



A shematic basin.

How does it work





Observed and predictec flows for 2000 and 2015 floods.

The mechanism will be described for a river but it is valid for any other dynamic model. We are confronted to a basin in which there are a number of stations s_i from *i = 1... k* and a downstream point P in which we want to predict over time flow. Clearly the number and location of the stations will affect the accuracy of the predictions but, initially, it may be sensible to restrict the analysis to a small number of stations. A short distance from the predictor station to the point *P* improves predictions accuracy but at the cost of weakening the usefulness of prevention. In many situations we can only play with the number of stations to be utilized, since the construction of new stations cannot be improvised. Figure 1 shows a typical network schematic diagram. The model is defined by two equations, one for the observations and another that characterizes the system state that is the flow *y_t* we want to predict. It contains two equations

Observation equation:

$Y_t = F'_t \theta_t + v_t$ where the error is normally distributed

Equation system:

$\theta_t = G \theta_{t-1} + w_t$ where the error is normally distributed

The idea of the observation equation is that the water passing through the point *P* at time *t* is equal to the water passing at the previous time multiplied by the system values plus an error due to values that are not observed in the basin.

The solution of the problem is a Bayesian one and the mechanism used is the Kalman´s Filter (196) which is a well-known technique in engineering. Once the observed real data are known this method allows correcting the predictions by taking into account the estimated errors.

Advantages

The advantages of the Bayesian application are that given the data *D*, it can handle the non-informative distributions of the unknown parameters and can perform the calculation of the final distributions of the system state distributions $\theta_{(t+h)}|_D$ and of the system observations $Y_{(t+h)}|_D$.

As shown in figure 2, it is feasible to produce predictions with six hours in advance of the flood which gives time enough to adopt or take actions that will reduce flood damage.

Where has it been developed

In order to make real predictions for the future, the research group in **Bayesian methods belonging to the Department of Statistics and Operations Research at the Complutense University** has developed the software PREDICAR for IBERDROLA SA Electricity Company that allows implementing the predictive models in a continuous time framework. The software becomes active as soon as the flow passes over a threshold set by the company. This program is owned by the company, but the same philosophy applies to any other context of prediction under uncertainty, such as investment appraisal, demand for electricity, economic investments, etc.

We are an interdisciplinary research group with members from different faculties at the Complutense, Carlos III and Rey Juan Carlos Universities. Currently the research group has 6 members and is led by Prof. Dr. Miguel Angel Gómez Villegas, from the Department of Statistics and Operations Research at the Faculty of Mathematics at the Complutense University.

And also

The research group organizes every three years an international workshop on Bayesian Methods. So far three workshops have been organized and a fourth BAYESIANS METHODS '17.MADRID workshop will be organized in Madrid in 2017.

Responsible Researcher

Miguel A. Gómez Villegas: villegas@ucm.es
Department: Statistics and Operational Research
Faculty: Mathematical Sciences