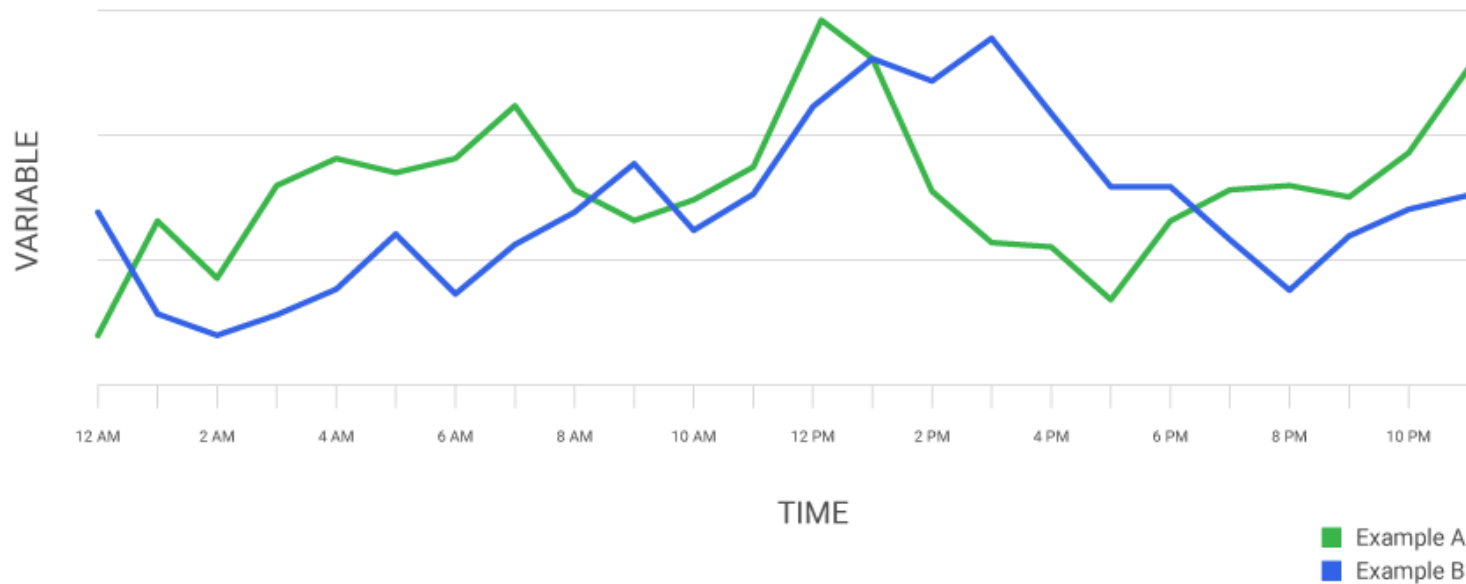# Online learning and time series

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What is a time series?

- A time series is time ordered (indexed) sequence of data points (e.g., measurements)

i.e., an ordered series of points $(t_0, \underline{x}_0), ..., (t_N, \underline{x}_N)$

Why is it important?

- Most commonly, a time series is a sequence taken at successive equally spaced points in time. Thus it is a sequence of discrete-time data.

- Time series data have a natural temporal ordering. In addition, time series models will often make use of the natural one-way ordering of time so that values for a given period will be expressed as deriving in some way from past values, rather than from future values
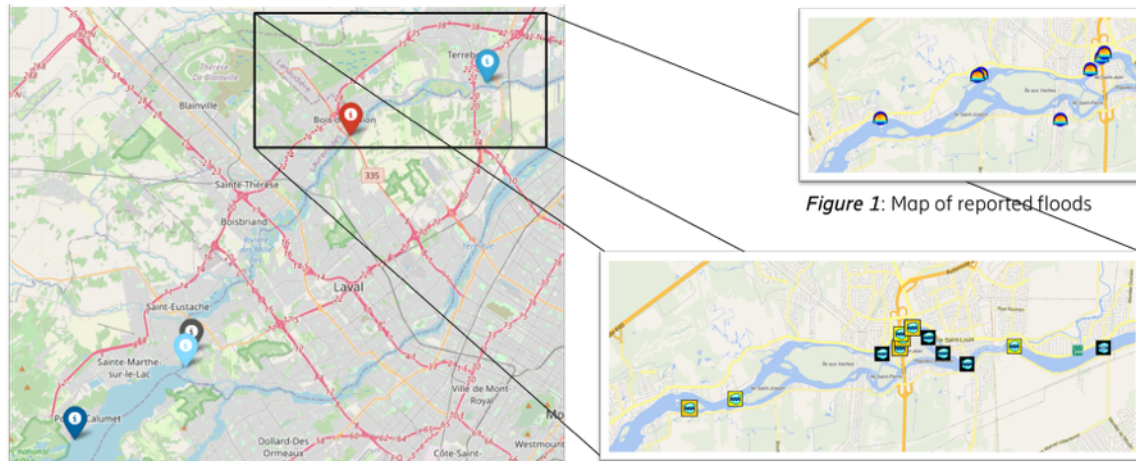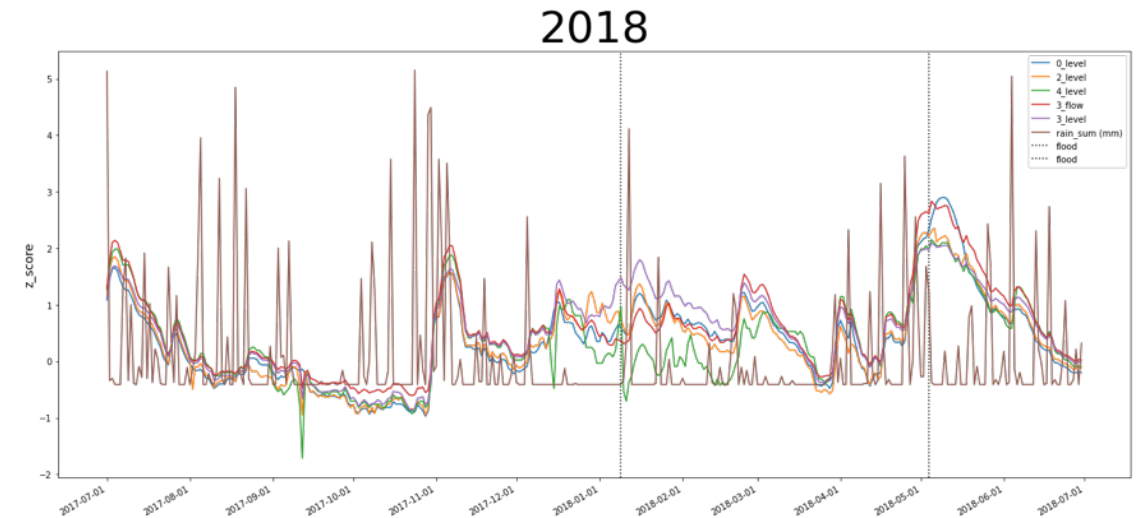
A concrete example of time series

Data available from 5 hydrometric stations at following locations. Federal station in red, Quebec stations in shades of blue/grey. Location of interest indicated with a rectangle

Figure 1: Map of reported floods

Figure 2: Map of reported ice events

Figures: Map of available hydrometric stations as well as locations of historical flooding and ice related events (top). Example of visualization of available water height and flows data, precipitations, and flooding events (bottom).

What is online learning?

- Online machine learning is a method of machine learning in which data becomes available in a sequential order and is used to update the best predictor for future data at each step.

- Online learning is a common technique used in areas of machine learning where it is computationally infeasible to train over the entire dataset.

Why is it important?

- In the era of big data, traditional batch learning paradigms become more and more restricted, especially when live data grows and evolves rapidly.

- Online learning overcomes the drawbacks of traditional batch learning in that the model can be updated instantly and efficiently by an online learner when new training data arrives.

- Besides, online learning algorithms are often easy to understand, simple to implement, and often founded on solid theory with rigorous regret bounds.

Problem definition

- Online (supervised) learning methods can be seen as a class of techniques which allow a ML model to learn from data that is coming on the fly. The model can be trained only a certain number N of observations at a time.

- All online techniques must specify a hyper-parameter known as the learning rate. No guidance is provided on how to fix this number. When too big, the model favors future observations while quickly forgetting past data. When too small, the model will favor past data and, consequently, have difficulties with learning from future observations.

- Some knowledge about the data can help at times but, for now, choosing this value remains an art. Thus, it would be highly desirable to have an automatic technique able to tackle this situation. Ideally, we would aim at a method which follows the same philosophy as the ADAM method.

References

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Thank You!