Big Data Project

Hertfordshire and North London Water Quality

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Outline

1. Data Exploration

2. Towards Time Series
   - Preprocessing
   - Modeling and Validation

3. References

Original Dataset

The original dataset contains 361101 samples (tuples) taken in the area nearby the Herfordshire and North London during a time span that goes from 2009 to 2016.
The measurements are sampled by the UK Environment Agency and other datasets are available **here**. Each tuple has the following fields:

- **_c0**: It's the row index, thus a progressive number
- **@id**: URI identifier
- **sample.samplingPoint**: The URI for making reference to a sampling point
- **sample.samplingPoint.notation**: A shorten string identifing each sampling point e.g.TH-PBRE9999
- **sample.samplingPoint.label**: The full name of the sampling point
- **sample.sampleDateTime**: The date and time when a sample was collected

Tuples’ Features cont.

- **determinand.label**: A brief string identifing the determinand sampled, which is the property measured
- **determinand.definition**: A string describing the determinand meaning, its definition
- **determinand.notation**: A string which uniquely identifies the determinand
- **resultQualifier.notation**: This feature can be empty or containing ”<”,”>” stating that is below or above the regulations
- **result**: The amount of the measured determinand
- **codedResultInterpretation.interpretation**: It is an empty column
- **determinand.unit.label**: The unit measure that expresses the **result** field

Tuples' Features cont. II

- **sample.sampledMaterialType.label**: The kind of material (strech of water, matter, ecc.) from which the determinand is sampled
- **sample.isComplianceSample**: It is a boolean to indicate whether the sample has been collected for a compliance purpose
- **sample.purpose.label**: The string describing the kind of the sampling purpose
- **sample.samplingPoint.easting**: The easting of the point on the British National Grid
- **sample.samplingPoint.northing**: The northing of the point on the British National Grid

Finding the most sampled pollutant...

- In order to find the most sampled and problematic determinand (pollutant), the **FPGrowth algorithm** is applied to the transactions grouped by sampling point and date.
- This frequent item algorithm yields **Ammonia(N)** as the most sapled, with a count of **17108** which is the 60% of the transactions.

...and its reason!

By analyzing the ammonia samples, it was mostly present in:

- Sewage effluents (5129 times)
- River/Running Surface Water (11080 times)

Which is the **95%** (16209/17108) of the times!
Especially the presence in the **river surface water** is meaningful since the Ammonia traces within water may come from:

- fertilizers
- food processing waste
- Industrial wastewater as non-conventional pollutant

The last two reasons can be both the reason since it implies the presence of industries, whereas the first cause would mean a high concentration of ammonia in the **undeground** water!.

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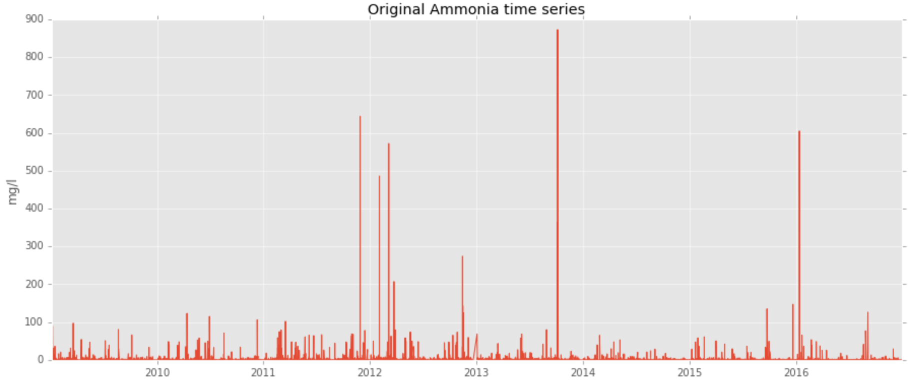
Original Time series



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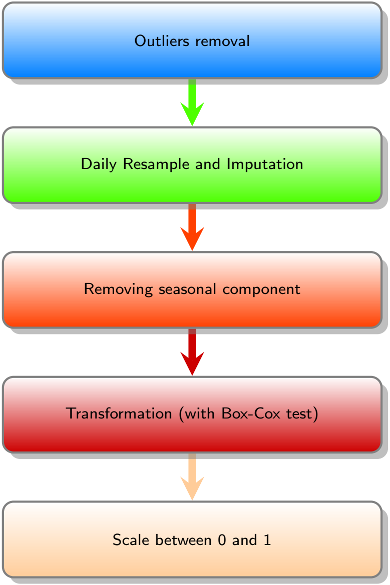
Pipeline



Outliers removal

Daily Resample and Imputation

Removing seasonal component

Transformation (with Box-Cox test)

Scale between 0 and 1

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ARMA Modeling

The **ARMA** model comes from statistics background.

- the AR is the **Autoregressive** part that takes in account of the previous steps equals to the AR's degree
- the MA is the **Moving Average** part that averages the stochastic side of the process equals to the MA's degree

Here, the **ARMA(2,1)** model is chosen by crossing two approaches:

- **AIC** (Akaike Information Criterion) and **BIC** (Bayesian Information Criterion) which are objective methods to select the degree that gives a good fit to the data preventing overfitting. This method computes gives the degree that enables the model to be enough complex to keep all the data's expressiveness
- **PACF** and **ACF**, the Partial AutoCorrelation Function and the AutoCorrelation Function are good indicators for finding out respectively the AR and MA degrees through a ”elbow analysis”.

Validation I: Whiteness test (or Anderson Test) of the error

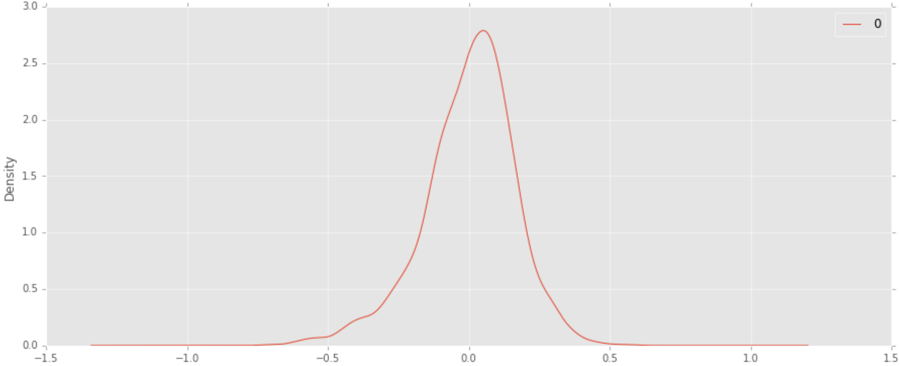

Figure: The error distribution is close to a Gaussian with mean 0 and variance 1

Validation II: Out-sample performances evaluation

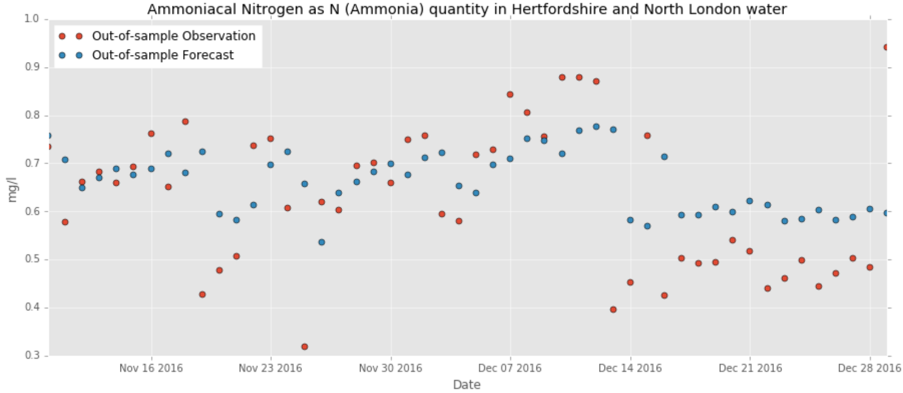

Figure: Mean Squared Error: 0.019193

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Guidelines

- **Spark and Pyspark doc**
- Spark understanding and basic knowledge from Big Data part held by prof. Ardagna during the Computing Infrastructures course @ Polimi
- **Statsmodels**: python module and its doc
- Notes from Model Identification and Data Analysis (MIDA/IMAD) course @ Polimi by prof. Bittanti and Savaresi
- **Statistical forecasting**: notes on regression and time series analysis by Robert Nau (Fuqua School of Business, Duke University)
- **Cross Validated**: Stack Overflow for stats guys in trouble