
Time Series Analysis and Prediction (TSAP) Análise de Séries Temporais e Predição (ASTP)

2024/2025

Project Assignment

Weather Time Series Analysis and Forecast

1 Background

Climate change is a hot topic that dominates the attention of the entire world. Analysing historical weather data enables us to find trends and seasonal patterns. Based on historical data, one can develop models and try to forecast future values. The goal is to find out from where we came, what the actual conditions are, and what we can expect in the future.

2 Data

Consider the data available at Open-Meteo.com-Historical Weather API (<https://open-meteo.com/en/docs/historical-weather-api>). Select a location (e.g., a city) and **daily weather** variables from 01-01-1940 to today. You can choose the variables that you see attractive, but **Mean Temperature** is mandatory. Be also aware that you must select a location different from the other groups. A problem that may arise is that the free access to the data is limited to some daily downloads. See this problem with the professor.

3 Objective

In the first phase, your task is to analyse and forecast the mean temperature at your chosen location. In the second phase, you must deal with multivariate problems and use additional time series (e.g., Precipitation).

4 Project main steps

You should apply the methods you learned during the course to your time series (only the ones that are suitable for it) and provide a critical analysis of the time series description, modelling, and forecasting. Consider implementing the steps described in the next subsection.

4.1 TS splitting

Split your TS into two: the first part of the TS should be used for characterization, modelling, and training, while some of the last parts of the TS should be used to assess the forecasting performance of your methods. The amount of data left for testing is something you should also define in the function of your TS.

4.2 Basic description techniques & transformations

Assume a decomposition model and describe your TS concerning trend, seasonality, and erratic component. Assess TS stationarity, and if not stationary, try to stationarize it.

4.3 Model fitting

Consider the different models studied and fit models to data and verify fitting quality. Note that not all the models studied may be useful, or even possible to be applied.

4.4 TS Forecasting

Use exponential smoothing and the fitted models to perform forecasting on the part of the data never used before. Report forecasting performances.

4.5 Multivariate modelling & Forecasting

Consider mean temperature and other TS. Compare them and evaluate their relationships. Apply multivariate models and perform mean temperature forecasts.

5 Documentation

You are requested to submit your report (max 20 pages). Write your article in an IMRaD format (Introduction, Methods, Results, and Discussion):

- Introduction:
 - Describe the “problem” you are addressing, why it is important, and the challenges facing.
 - Describe the dataset you worked with.
- Methods:
 - Describe the methods you used to characterize, model, and forecast the TS and how you analysed and validated your result.
- Results:
 - Show the results you obtained. Represent them in plots and/or tables.
- Discussion & Conclusion:
 - Discuss your results.
 - Derive some conclusions
 - Identify future steps to develop the work, so others can build upon your research

Besides those sections, you must provide an abstract, title, author identification on the first page, and references after conclusions. Your report’s main body should describe and summarise the main results. Exhaustive project results and code may be included in appendices after references.

5.1 Requirements

The practical assignment is meant to be done in groups of two persons. Groups of three persons may be allowed if the course has an odd number of students.

5.2 Project Submission & Deadlines

1. Project First Milestone (**Deadline: 24th October 2024!**)

Deliverables:

- Basic description and transformations;

2. Project Final Goal (**Deadline: 6th December 2024!**)

Deliverables:

- All the work developed described in a report, including the one reported in the first milestone.

3. Presentation and Discussion (**Classes of 12th December 2024!**)

Citation & Acknowledgement

- Zippenfenig, P. (2023). Open-Meteo.com Weather API [Computer software]. Zenodo. <https://doi.org/10.5281/ZENODO.7970649>
- Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horányi, A., Muñoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thépaut, J-N. (2023). ERA5 hourly data on single levels from 1940 to present [Data set]. ECMWF. <https://doi.org/10.24381/cds.adbb2d47>
- Muñoz Sabater, J. (2019). ERA5-Land hourly data from 2001 to present [Data set]. ECMWF. <https://doi.org/10.24381/CDS.E2161BAC>
- Schimanke S., Ridal M., Le Moigne P., Berggren L., Undén P., Randriamampianina R., Andrea U., Bazile E., Bertelsen A., Brousseau P., Dahlgren P., Edvinsson L., El Said A., Glinton M., Hopsch S., Isaksson L., Mladek R., Olsson E., Verrelle A., Wang Z.Q. (2021). CERRA sub-daily regional reanalysis data for Europe on single levels from 1984 to present [Data set]. ECMWF. <https://doi.org/10.24381/CDS.622A565A>