

Enhancing the temporal resolution of climate models outputs represented by diffusion processes

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To study the impact of global warming on the electricity system (supply-demand balance, for example), it is necessary to use the outputs of the various CMIP6 climate models (temperature, wind speed, for example), which are projected to the end of the century (see the 6th IPCC assessment report). However, because of the high numerical costs involved, the outputs of these models are only available at spatial ($\sim 100\text{km}$) and temporal (day) resolutions that are too low, and also present modelling biases (not all physical phenomena are represented). In this work, we are interested in the problem of temporal resolution: for certain impact studies, such as the projection of wind generation into the future, it is necessary to have hourly data.

Such problems also show up in energy market perspective, where one would like to simulate price scenarios at an hourly level starting from a coarser simulation grid.

One approach proposed here is to model the variable of interest by a stochastic differential equation:

$$dX_t = \mu(X_t, t)dt + \sigma(X_t, t)dW_t,$$

with $(W_t)_t$ a Brownian motion, a model used for example for temperature in Alfonsi and Vellido (2024). Given the observation each day $J_i = [t_i, t_{i+1}]$ of $\inf_{s \in J_i} X_s, \sup_{s \in J_i} X_s, |J_i|^{-1} \int_{J_i} X_s ds$, the objective is twofold:

- develop a method for estimating μ and σ (we will use a parametric model),
- develop a method for simulating X_t on a grid with a higher resolution than $(t_i)_i$, conditional on the observed data.

Depending on the progress made, the case of dimensions greater than 1 may be considered.

References

- Alfonsi, Aurélien, and Nerea Vellido. "Risk valuation of quanto derivatives on temperature and electricity." *Applied Mathematical Finance* 30.6 (2023): 275-312.