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Continuous simulation of hourly areal rainfall over a wide range of French catchments: methodology, applications and validation at multi-temporal scales.

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Abstract

Rainfall represents one of the most complex climatic variable to model, owing to its marked spatiotemporal variability, intermittency, the extreme amplitude of rare events, and the limitations of observational datasets-particularly at fine temporal resolutions. Robust analysis of hydrometeorological risks therefore requires tools capable of faithfully reproducing the structure of precipitation, which varies strongly across timescales, for a range of values from frequent, moderate rainfall to rare, extreme events.

Fine-timescale rainfall series generators directly address this need by generating realistic time series essential for feeding hydrological models and assessing the impact of rainfall events on watersheds. These synthetic rainfall series enable exploration of hydrological responses to various scenarios, integrating interannual variability, seasonality and temporal autocorrelation of rainfall at multiple timescales.

The generator proposed in this study is designed to replicate the full range of temporal characteristics of rainfall, from hourly to annual scales. It is based on an event-based model that simulates significant rainfall episodes at an hourly time step, embedded within a continuous series that incorporates dry inter-event periods and lower-intensity rainfall. Calibration was conducted using areal rainfall series whose temporal structure varies depending on the spatial aggregation scale.

The generator's performance is assessed at various temporal resolutions, from hourly to annual, by evaluating its ability to reproduce key rainfall properties including seasonality, temporal autocorrelation, and quantile distribution, from moderate to extreme values. Applied to over 2,100 watersheds, ranging in area from 1 to 10,000 km², the model demonstrates robust performance for simulating the different temporal characteristics of rainfall in highly contrasting climatic contexts.

These long hourly rainfall synthetic rainfall series, respecting precipitation properties at different scales, will be used to drive a hydrological model to produce long hourly synthetic flow series. Such simulations are essential for the robust assessment of hydrological hazards and risk mitigation.

Keywords: hourly rainfall generator, areal rainfall, multi, temporal scales

*Speaker

Next-Gen Climate Projections for Switzerland: Blending Bias Correction with Machine Learning across Scales

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Abstract

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Regional climate models (RCMs) are key tools for projecting future climate, but their coarse spatial resolution (e.g., 12 km EURO-CORDEX ensemble) limits their usability for local impact studies. Machine-learning (ML) downscaling pipelines (both deterministic and generative) offer a promising complement to dynamical methods for kilometer-scale projections.

Firstly, we investigate three bias-correction approaches alongside deterministic and generative ML architectures to produce 1 km Swiss climate scenarios from the EURO-CORDEX 12 km ensemble. Four climate fields are downscaled using the MeteoSwiss Spatial Analysis as target data: daily mean temperature, daily maximum and minimum temperature, and daily precipitation. We combine dynamical Optimal Transport Correction (dOTC) for bias correction with a residual U-Net for super-resolution. Baselines include empirical quantile mapping for bias correction and bicubic interpolation for super-resolution. When evaluated for the standard climatological period (1981-2010), we find significant improvements in the representation of interannual cycles, decadal variability, and distributional tails, as quantified by 20, 50, and 100-year return levels across climate regimes represented by cities such as Bern, Geneva, Locarno, Lugano, and Zürich.

Secondly, beyond coupling RCMs with bias correction and super-resolution, we assess whether emerging generative ML approaches, such as latent and heavy-tailed diffusion, can directly generate realistic ensembles of kilometer-scale climate fields from CMIP6 model outputs. After an intermediate bias-correction step, we map coarse prognostic fields to the four kilometer-scale targets. Overall, we show that (1) multivariate bias correction remains essential to preserve statistical fidelity across spatial scales, and (2) residual ML methods hold promise for actionable, high-resolution information on climate timescales.

Keywords: Climate Change, Climate Downscaling, Generative Models, GCMs, RCMs, Climate Scenarios

^{*}Speaker

An Open Source Weather Generator for Downscaling Climate Model Outputs

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Abstract

We present a multi-site weather generator with a stochastic rainfall field generator at its core. The weather generator is developed with the motive to produce downscaled projections for the future by utilizing the suite of climate models from the CMIP5/6 archive. The rainfall fields are sampled from a spatio-temporal Neyman-Scott Rectangular Pulse (NSRP) process. When considering a single site, the NSRP model parameterizes storm arrivals as a poisson process and storm separation time as exponential distribution. Each storm is assigned a certain number of raincells (a poisson random number) with each raincell having a duration and intensity which are exponentially distributed. For a multi-site model, additional considerations are made which include the radius of raincell parameterised by exponential distribution and the raincell density as a uniform poisson process (which is a replacement to the raincell generation process of single site model). For the single site model capturing the mean monthly rainfall totals, daily variance, skewness, lag-1 autocorrelation, dry-day proportion and daily annual maximums are considered to be of paramount importance. Whereas for the multi-site model, its efficacy in capturing intergauge correlations is emphasized. The developed rainfall generator has shown its efficacy in capturing the statistics of the observed rainfall across point and catchment scales. Following the calibration and testing of the NSRP-based rainfall generator, the other weather variables such as temperature and wind speed are ascertained through regression relationships by considering wet and dry states. The climate model downscaling is then initiated by computing multiplicative and additive change factors for rainfall and temperature respectively. Overall, the developed weather generator can provide multiple plausible future scenarios which shall aid in climate change impact assessment and adaptation planning.

Keywords: Neyman, Scott Rectangular Pulse (NSRP), Downscaling, Change Factors

^{*}Speaker

Univariate Stochastic Modeling of Rainfall Extremes in Montpellier

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Abstract

Flood risk is particularly high in urban areas due to soil impermeability, which prevents water absorption. Flooding can occur after periods of intense rainfall or during prolonged episodes of moderate rain. A precise understanding of such events is therefore necessary to control this risk. This is especially true in Montpellier, where heavy precipitation events frequently result in urban flooding.

In this context, the modeling of rainfall patterns plays a crucial role. Over time, statistical approaches such as the use of Exponential, Gamma, or Poisson-type distributions have been widely employed to model daily or hourly precipitation data. These methods offer flexibility in fitting a range of rainfall characteristics. While it performs well across the full range of values, it fails to accurately capture extreme events. Following extreme value theory, large values can be modeled by a Generalized Pareto Distribution (GPD), which corresponds to the limit of threshold exceedances when the threshold goes to infinity. However, in a statistical setting, this approach faces the choice of an appropriate threshold, which is a challenging issue. An extended version of the GPD (EGPD) has therefore been proposed to model the entire range of the rainfall intensities without choosing any threshold. This model is however unable to capture dry periods since it relies on a continuous distribution.

In this work, our goal is to model univariate rainfall at a high temporal resolution and by taking into account dry periods, moderate, and heavy rainfall. The data we use comes a network of 17 rain gauges that has been deployed across the Verdanson watershed in Montpellier by the Urban Observatory. This measuring system has generated a large, high-frequency data collected at one-minute intervals since 2019. In order to properly model this high resolution, we use a discrete model based on the EGPD, called the Discrete Extended Generalized Pareto Distribution (DEGPD). While it provides some accurate results when fitting it to the data, this distribution still fails to properly capture the high frequency of zeros in our dataset, even when a zero inflation method is applied. To address this issue, we develop a hurdle model, which separates the modeling of zero rainfall from that of positive values. Among the two common strategies - truncation and shifting - we choose the shifted approach. The results of the fitting procedures on our dataset support the use of the previously proposed distribution in modeling this type of data. However, incorporating temporal dependence remains a challenge, as the current distribution is not easily extendable to time series.

Keywords: Extreme value theory, rainfall modeling, DEGPD, hurdle model, univariate modeling

^{*}Speaker

GRAFFAS: A Stochastic Space-Time Model for High-Resolution Hourly Rainfall Fields

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Abstract

We propose GRAFFAS (Generator of RAInfall Fields From Areal Statistics), a stochastic space-time model designed to simulate hourly rainfall fields at fine spatial resolution (down to km²), from areal statistics time series. The spatial disaggregation approach used in GRAFFAS enables the representation of spatial heterogeneity and anisotropy, which are essential features in many regions.

A multivariate auto-regressive Gaussian process is used to model the space-time dependencies of fields, including anisotropy. Then, a meta-model combines the simulated Gaussian fields and the areal rainfall statistics to provide synthetic rainfall fields. Local parameters are introduced within this meta-model and allow spatial heterogeneity to be reproduced.

The model is calibrated and evaluated using kilometric hourly rainfall data across six climatically contrasting regions. The evaluation framework assesses the model’s ability to reproduce key statistical properties of rainfall across temporal and spatial scales. Results highlight the importance of spatial heterogeneity in reproducing at-site rainfall distributions (including extremes) and the co-occurrence of extreme events across a region at different aggregation timescales.

Keywords: stochastic space, time model, rainfall fields, meta, Gaussian model, spatial disaggregation

^{*}Speaker

Bayesian mixture models for heterogeneous extremes

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Abstract

The conventional use of the Generalized Extreme Value (GEV) distribution to model block maxima may be inappropriate when extremes are actually structured into multiple heterogeneous groups. This can result in inaccurate risk estimation of extreme events based on return levels and in inaccurate generation of maxima based on unrealistic models. In this work, we propose a novel approach for describing the behavior of extreme values in the presence of such heterogeneity. Rather than defaulting to the GEV distribution simply because it arises as a theoretical limit, we show that alternative block-maxima-based models can also align with the extremal types theorem while providing improved robustness and flexibility in practice. Our formulation leads us to a mixture model that has a Bayesian nonparametric interpretation as a Dirichlet process mixture of GEV distributions. The use of an infinite number of components enables the characterization of every possible block behavior, while at the same time defining similarities between observations based on their extremal behavior. By employing a Dirichlet process prior on the mixing measure, we can capture the complex structure of the data without the need to pre-specify the number of mixture components. The posterior distribution can also be used to generate climate maxima that reflect the heterogeneity observed in real data. The application of the proposed model is illustrated using both simulated and real-world climate data.

Keywords: Bayesian nonparametrics, Dirichlet process mixture, Extreme value theory, Heterogeneity

^{*}Speaker

EGPD, second-order regular variation and disaggregation

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Abstract

In hydrology, the computation of return levels is usually performed in a twofold manner, by modelling separately high values and the bulk of the distribution. Such an approach has two issues: the models used to deal with each part of the distribution may not be consistent with the other, and finding a systematic method to choose an optimal threshold between those two regimes often proves difficult. The extended generalized Pareto distribution (egpd) proposed by Naveau et al. (2016) treat these two issues by replacing the dividing cutoff (threshold section) with a smooth transition from low to high values. While being compliant with extreme value theory, the mathematical second order properties of this egpd remains unknown. In particular, this probability aspect represents a key element in rainfall aggregation modeling, say from sub-hourly to weekly, and consequently, in the computation of the well known Intensity-Duration-Frequency (IDF) curves used in flood risk designs. In this context, we propose sufficient conditions for the egpd to possess the second-order regular variation property. We will also explain how these mathematical findings play a practical role in convolution. Adding positive random variables with heavy tails is a fundamental operation within any multi-scale (either in time or space) rainfall stochastic weather generators (SWG). This novel understanding of aggregation should help practitioners to improve or test existing rainfall SWGs.

Keywords: egpd, second, order regular variation, aggregation, POT method

^{*}Speaker

Stochastic weather generators coupled with soil physics models for rare-event estimation: application to groundwater recharge in Nevada (USA)

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Abstract

Episodic rare precipitation events of high intensity strongly shape groundwater recharge and water availability in arid regions, yet projections of climate impacts on subsurface hydrology often rely on averaged (monthly or seasonal) predictions. We investigate how rare-event probabilities of groundwater recharge derived from scale-aware, stochastic boundary conditions compare with those obtained from temporally averaged forcings. Here we coupled an hourly stochastic weather generator with two vadose-zone simulators to represent decadal results from an experimental facility near Las Vegas, Nevada. Meteorological boundary conditions are produced using AWE-GEN (Advanced WEather GENerator), an hourly stochastic weather generator combining empirical statistical relations and physically-based components. From these outputs, we compute potential evapotranspiration with FAO-56 Penman–Monteith. With these inputs, we simulated groundwater recharge using two alternative vadose zone models: (i) SEC (Surface Evaporation Capacitor), a bucket model of near-surface storage and fluxes that includes state-of-the-art understanding of soil evaporation processes; and (ii) HYDRUS-1D, a Richards-equation solver for layered media allowing the simulation of detailed unsaturated-zone dynamics, where evapotranspiration is handled by the upper boundary condition for soil evaporation and a distributed sink term for root water uptake inside the soil profile. The case study focuses on the unique SEPHAS observatory that includes long-term records of weighted lysimeters and TDR-based soil moisture, as well as meteorological variables in terms of radiation, humidity, temperature, wind, and precipitation. After calibrating AWE-GEN to this site, we evaluate SEC and HYDRUS across (a) recharge frequency distributions and event magnitudes, (b) seasonal evaporation partitioning and potential evapotranspiration consistency during energy-limited periods, and (c) sensitivity to soil parameters and upper/lower boundary conditions. Next, we plan to focus on rare-event metrics, such as annual groundwater-recharge exceedance levels, multi-week Stage-II (soil-limited) evaporation durations, and extreme rainfall thresholds. To target rare

^{*}Speaker

event probabilities efficiently, we incorporate Adaptive Multilevel Splitting (AMS), a rare-event simulation method from probability/statistical physics, in our modeling framework. This technique adaptively concentrates computation on trajectories that approach the rare event by cloning those that make progress and pruning those that do not while accounting for probabilities using importance sampling theory.

Keywords: Groundwater recharge Rare events Extreme precipitation Stochastic weather generator (AWE, GEN) Vadose zone modeling (SEC, HYDRUS, 1D) Adaptive Multilevel Splitting (AMS) Evapotranspiration (FAO, 56 Penman–Monteith) Arid regions (Nevada, SEPHAS)

Comparing a statistical weather generator and multiple runs of global climate models to characterize hydrological low flows: A case study in the Loire catchment (France)

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Abstract

Understanding and quantifying severe low flows is crucial for the management of hydropower or thermal power plants. Moreover, low flows are strongly related to the climatic regime and will be affected by climate change. However, the strong interannual variability of low flows, combined with the limited length of observational records, hinders robust characterization based solely on historical data. Hydrological modeling offers an alternative to provide long timeseries of pseudo-observation but require long term meteorological inputs such as precipitation and temperature.

This study explores two approaches to generate long meteorological time series: (1) statistical weather generators calibrated on in-situ observations, and (2) ensembles derived from two global climate models, each comprising 50 members following the SMILEs method (Single-Model Initial-condition Large Ensembles). Both climate datasets are used to drive a lumped conceptual hydrological model, MORDOR-SD, to simulate long-term daily discharge series. The analysis focuses on the Loire River catchment in central France over the 1955–2015 period.

The resulting precipitation, temperature, and discharge time series are compared, with particular attention to low-flow characteristics. The comparison emphasizes annual minima (and maxima for temperature) over multi-day periods, with analyses of trends and return period estimations. The study highlights the strengths and limitations of each approach, both in terms of usability and their ability to produce robust estimates of low-flow characteristics for various return periods.

Keywords: weather generators, gcm, hydrological modeling, precipitation, temperature, discharge

^{*}Speaker

Rainfall, volatility and roughness: an intriguing story across scales

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Abstract

Joint work with Marc Hoffmann (CEREMADE, Université Paris Dauphine - PSL) **Résumé** : Hydrologists have long modelled rainfall with discrete or continuous time models based on point processes. In a first part, we show that most of the desired phenomenological properties of rainfall models are captured by Hawkes processes. Viewing this approach as a microscopic modelling, we zoom out in a second part our data to build a macroscopic model of aggregated rainfall. On several macroscopic data sets, we empirically establish that rainfall behaves like a rough fractional process with Hurst parameter close to 0.1; we further rigorously analyze the compatibility of this modelling across time scales, implying a heavy-tailed behavior for the accompanying microscopic Hawkes model. As a consequence, an unexpected analogy of the theory of rough volatility of Gatheral and Rosenbaum seems to emerge for rainfall modelling. We further discuss these findings from a statistical point of view, in particular how they advocate for the need of better tools for analyzing nonstationary data.

Keywords: Rainfall, Point process, Hawkes process, Fractionnal brownian motion, volatility

*Speaker

Simulation of extreme functionals in meteoceanic data

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Abstract

The role of meteoceanic conditions is crucial in coastal flooding. Our objective is to simulate new observations that have the same behaviour as the observed conditions but are extrapolated towards high values. The motivation is to enhance the modelling of coastal flooding by a design of experiments (Rohmer et al. 2022) where the inputs of such numerical models are time series. We work specifically on the site of Gâvres in French Brittany and use a database based on the paper of (Idier et al. 2020). This small town being located in a macro-tidal area, we focus on meteoceanic conditions occurring $(+/-)3h$ around the high tide (with a fixed time step of 10 minutes). Thus, we are interested in the evolution of forcing conditions over tidal cycles and our database consists of time series of length 37 at different events. We use the notation X_tM to describe the value obtained at time t for the M th tidal cycle.

Our observations do not meet the standard assumptions of independence and regular variations. The first step of our method thus consists in a "whitening" pre-processing of the data. We focus on detrended winter time series $\tilde{X}_tM$. Then, we impose a minimal duration between each event and introduce an autoregressive model with residuals ϵ_tM to account for the temporal dependence between tidal cycles while preserving the dependence within each one of them. In a second step, we show how to combine the approach of (Opitz, Allard, and Mariethoz 2021) and (Clémenton, Huet, and Sabourin 2024) to simulate new extreme residuals. This involves a marginal transformation T to meet the assumption of regular variations. Finally, we apply the reverse transformations and show how to simulate extreme time series, verifying $(T(\epsilon_tM))_{t=1}^n > u$ where $\|\cdot\|_2$ is the L2 norm. This step depends on an initial time series $\tilde{X}_tM$, that can be chosen to tune the desired level of extremes.

We apply our method to the surge data and generate simulations of extreme time series. Since we use autoregressive models and we aim to obtain realistic extreme simulations, we use the level of (ϵ_{sim}) to draw $\tilde{X}_tM$. We assess the quality of our method by checking that simulations and extreme observations share common behaviours. First of all, they should have shape similarities. As the simulations extrapolate the L2 norm of the observations, we apply PCA on the normalized data $\tilde{X}_tM/(\|\tilde{X}_tM\|_2)$. The simulated time series generally behave the same way as the extremes observations as their respective coordinates are close.

^{*}Speaker

Then, we apply two-sample classification tests (Lopez-Paz and Oquab 2016; Watson et al. 2023), to assess whether a classifier can distinguish between the observed and simulated time series. Given we have $n = 259$ extreme time series in the database and we simulate $n_{\text{sim}} = 2,000$ extreme time series, we estimate a confidence interval for the rate of correct prediction. Since the value 50% often lies within these intervals for several classifiers, our simulations are consistent with the observations.

Keywords: Extreme values, Pareto processes, Regular variations, Autoregressive models

Investigating the Upper Limit of ML-Based Stochastic Discharge Simulations

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Abstract

Machine learning (ML) hydrological models, particularly Long Short-Term Memory (LSTM) networks, have shown remarkable potential in accurately simulating streamflow. This study explores the capacity of regional ML models to extrapolate beyond their training data range by integrating stochastic precipitation from a weather generator into an LSTM hydrological model. Previous research by Jankowsky et al. (2025) demonstrated that LSTM models extrapolate well with stochastic precipitation when a sufficiently large training dataset is used for gauges.

In this study, we aim to determine whether this finding holds for gauges near the upper limit of specific discharge (discharge per upstream area) of the modelled range. We utilize global and continental datasets comprising several thousand discharge gauges to conduct our investigation. The study examines the impact of different model structures, objective functions, and scaling techniques on the upper specific discharge limit. These tests reveal the importance of scaling techniques on the extrapolation capacity of the model. The study also confirms the earlier findings that the size of the training data set and the training strategy has a major influence on the upper limit of the model. Furthermore, as the specific discharge increases with smaller upstream area, it is important to include gauges on small tributaries into the training data set. Our tests show that with the right configuration, the upper limit can be pushed to reasonable physical limits allowing the model to be used for stochastic simulations.

Jankowsky, S., Kanneganti, G., Li, S., Hilberts, A. Assteerawatt, A., Evaluation of LSTM Model for Stochastic Discharge Simulation. EGU General Assembly 2025, Vienna, Austria, 27 Apr–2 May 2025, <https://doi.org/10.5194/egusphere-egu25-15152>.

Keywords: Machine learning, hydrology, discharge simulation

^{*}Speaker

Modeling simultaneous flooding in river networks with precipitation covariates using Hüsler–Reiss graphical models

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Abstract

This study focuses on the risk of simultaneous flooding in river networks. The objective is to develop a graphical model that integrates climate variables as covariates in order to estimate extreme river flow values under specific climatic conditions. To capture the dependence structure of extremes across multiple sites and basins, we employ the Hüsler–Reiss graphical model for multivariate extremes which identifies conditional dependencies between rivers and covariates. First, we investigate the spatial relationships between extremes of precipitation and river flows within a watershed using the Hüsler–Reiss graphical model. This allows us to characterize dependencies between river flow stations, between precipitation locations, and between precipitation and river flows. Building on this framework, we propose a novel semi-imposed approach: part of the graphical structure is pre-specified based on hydrological knowledge, while the remaining edges and the model parameters are learned from the data. This balance aims to achieve a model that is both interpretable and computationally efficient.

Keywords: Graphical model, Multivariate extreme events, Hüsler–Reiss distribution, Flood risk, Climate covariates

^{*}Speaker

The challenges of modelling extreme precipitation and floods from a user's perspective

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Abstract

Reinsurance is insurance for insurance companies, allowing them to transfer part of their risk to reinsurers. This helps insurers manage large losses, stabilise finances, and increase underwriting capacity.

Catastrophe (cat) models are tools used in the insurance and reinsurance industry to assess and quantify the risk of large-scale natural disasters affecting insurance portfolios. These models help to understand potential loss scenarios, estimate probable maximum losses, and evaluate the financial impact of catastrophic events.

The principle of cat models is to simulate and quantify the potential financial impact of rare but severe catastrophic events—such as hurricanes, earthquakes, floods, or other natural disasters—on insured assets. These models combine hazard data, exposure information, vulnerability assessments and insurance and/or reinsurance financial terms to estimate probable losses for different perspectives: i.e. for the insureds, the insurer and the reinsurers.

Guy Carpenter, as a reinsurance broking firm, acts as an intermediary, connecting insurers with reinsurers. It provides expertise to insurance companies to assess their risk, negotiate terms, and structure reinsurance programs tailored specifically to them.

For this purpose, Guy Carpenter is building its own view of the risk that integrates vendor as well as its internally developed GCAT cat models. GCAT models exist for different natural perils: flood, earthquake, tropical cyclone, severe convective storms, freeze, hail, wildfire.

This poster aims to present the perspective of a user engaging with scientific advancements in extreme precipitation for the specific use within cat models, with a particular emphasis on flood modelling. Some of the key challenges in developing flood cat models include ensuring the comprehensiveness and plausibility of extreme precipitation events, addressing the scale mismatch between localised hazards and broader reinsurance programs (which operate at country or regional levels), and accurately representing current hazard conditions amid a changing, non-stationary climate.

Keywords: risk management, reinsurance, catastrophe models

*Speaker

A sub-hourly spatio-temporal statistical model for solar irradiance in Ireland using open-source data

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Abstract

In today's changing climate, one of Ireland's greatest challenges is achieving the target of decarbonising the national energy grid by 2050. Expanding renewable energy capacity, particularly through harnessing solar power, is central to this transition. By December 2024, nearly 100,000 Irish homes had installed solar panels. However, renewable power generation is highly variable. To maximise renewable integration into the grid, accurate real-time predictions of solar power generation are essential.

A key component of this is the reliable estimation of solar irradiance, which underpins the modelling of solar photovoltaic (PV) power output. In Ireland's highly variable maritime climate, where ground-based measurement stations are sparsely distributed, identifying suitable solar irradiance datasets remains a major challenge.

Our research introduces a Bayesian spatio-temporal modelling framework to predict solar irradiance at both hourly and sub-hourly (10-minute) resolutions across Ireland. We validate our approach through cross-validation, including leave-one-site-out testing, demonstrating strong statistical robustness. In comparative studies, our model consistently outperforms alternative approaches such as reanalysis datasets and nearest-station interpolation. We then can extend solar irradiance estimates to solar power generation at hourly and sub-hourly resolutions. At the sub-hourly scale, 10-minute resolution estimates align closely with observed solar PV power outputs from residential and industrial installations in Ireland. Beyond improved accuracy, our framework provides full uncertainty quantification, scalability, and the potential for real-time implementation.

Keywords: Solar irradiance, Bayesian, Spatio, temporal, Solar Power, Uncertainty Quantification

^{*}Speaker

Non-stationary meta-Gaussian process for daily downscaling of precipitation: NSGPDS

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Abstract

Given the coarse spatial resolution of general circulation models (GCMs), finer-scale downscaling rainfall projections are needed to drive impact models, for example, in hydrology or ecology, among other fields, for risk estimation of floods and their impacts on infrastructure networks, water resource management, or land-use in a climate change context. This study aims to develop a downscaling model accounting for climate spatio-temporal non-stationarities. The model developed in this study relies on a single transformed and truncated Gaussian process to model rain fields (including both occurrences and intensities). The novelty of this work resides in: first the use of a censored likelihood to take into account the spatial and temporal intermittency of rainfall in the estimation of the covariance structure, second the use of a non-stationary covariance function allowing the introduction of spatial and temporal non-stationarities in the dependence structure and third the possibility to upscale rain fields at any target spatial resolution from rain gauges data. A perfect model experiment framework is adopted to evaluate the model's ability to reproduce spatio-temporal non-stationarity. The model is applied around the French Mediterranean covering a 91260 km² basin.

Keywords: Non, stationary, meta, Gaussian, downscaling, precipitation

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