

Gaussian Copulas for Large Spatial Fields

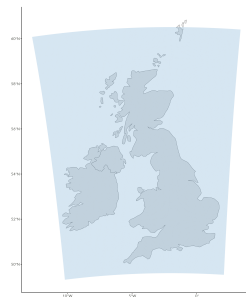
Modeling Data-Level Spatial Dependence in Multivariate Generalized Extreme Value Distributions

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Introduction

- ▶ UKCP Local Projections on a 5km grid over the UK (1980-2080)
- ▶ Challenge: Modeling maximum daily precipitation in yearly blocks
 - ▶ 43,920 spatial locations on a 180 x 244 grid
- ▶ Two aspects of spatial dependence:
 1. GEV parameters (ICAR models)
 2. Data-level dependence (Copulas)



Calculating Multivariate Normal Densities

Log Density Formula

$$\log f(\mathbf{x}) \propto \frac{1}{2} (\log |\mathbf{Q}| - \mathbf{x}^T \mathbf{Q} \mathbf{x})$$

Key Components

1. **Log Determinant:** $\log |\mathbf{Q}|$
 - ▶ Constant for a given precision matrix
2. **Quadratic Form:** $\mathbf{x}^T \mathbf{Q} \mathbf{x}$
 - ▶ Needs calculation for each density evaluation

Computational Challenges

- ▶ Log determinant calculation
 - ▶ Time complexity: $O(n^3)$ for naive methods
 - ▶ Memory complexity: $O(n^2)$
- ▶ Quadratic form calculation
 - ▶ Time complexity: $O(n^2)$
 - ▶ Critical for performance in large spatial fields

Spatial Model Considerations

- ▶ Some models (e.g., ICAR) avoid log determinant calculation
- ▶ Efficient computation crucial for large-scale applications