**Titel:**

Motion Field Forecasting and Ensemble Generation in Rainfall Nowcasting. A Data-Driven Approach

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**Author:** D.A. Blázquez Martín

**Abstract**

This thesis aims to enhance rainfall nowcasting by improving motion field predictions and ensemble generation within PySTEPS using machine learning techniques. Accurate nowcasting is crucial for flood early warning, agriculture, transportation, and public safety. The steady-state assumptions and ensemble generation in PySTEPS, and many other nowcasting methods, face significant challenges in maintaining accuracy over time, especially during convective weather events characterized by rapid changes in precipitation patterns and their movement. The research focuses on three objectives: identifying the current errors and uncertainties in PySTEPS motion field estimations, constructing dynamic motion field predictions with the development of a new deep-learning model, MotioNNet, and developing motion field ensemble generation methods for MotioNNet.

We introduce a new dataset containing 10,000 motion field events, consisting of events with high rainfall and motion errors in the NL. MotioNNet, trained/validated/tested on 75%/12.5%/12.5% of the dataset, improves motion prediction accuracy by approximately 13%. It provides accurate temporal adjustments (e.g., advecting the motion), especially in structured and stable events. For ensemble generation, probabilistic techniques such as SpatialDropout and Monte Carlo dropout are employed within MotioNNet. The results indicate better ensemble predictions in structured and stable events, accurately identifying problematic areas and generating realistic members. However, it presents a small spread compared to PySTEPS. Challenges remain in accurately capturing uncertainty during highly dynamic convective events, but new paths are open for future enhancement.

The study concludes that integrating machine learning models into traditional nowcasting frameworks can substantially enhance motion field predictions and ensemble generation. Future work should focus on further refining these models or exploring more advanced architectures (e.g., ConvLSTM, diffusion models, or transformers), improving context-dependent perturbations in ensemble generation, and enhancing the references and assessments. These advancements hold potential for improving motion field nowcasting accuracy.