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Doctoral Dissertation
Doctoral Program in Environmental and Civil Engineering (37^{th}cycle)

Novel post-processing applications in weather science

By

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Synthesis

This thesis explores the pivotal role of post-processing in weather science, emphasizing its ability to correct biases, reduce uncertainties, and enhance the interpretability of model outputs across different spatial scales. Despite improvements in numerical modeling, raw model outputs often remain flawed due to systematic biases and structural errors.

The first part (Chapters 2–3) addresses high-resolution, limited-area post-processing of daily cumulated precipitation forecasts. It introduces a multi-model machine learning approach that blends outputs from different Numerical Weather Prediction (NWP) models to improve forecast accuracy and robustness. Chapter 2 targets aleatoric uncertainty using deterministic deep learning models (MLPs and U-Nets), while Chapter 3 incorporates epistemic uncertainty via probabilistic networks like deep ensembles and Monte Carlo dropout, enhancing reliability for risk-sensitive applications.

The second part (Chapter 4) shifts focus to a global-scale application: correcting water budget inconsistencies in the dataset from the Lagrangian moisture tracking model UTrack. Using Iterative Proportional Fitting, the improved RECON dataset is provided. It ensures consistency with ERA5 reanalysis while preserving spatial dynamics.

Together, these case studies demonstrate how integrating machine learning, statistical methods, and physical constraints in post-processing strengthens forecast performance, supports uncertainty quantification, and aids in hydrometeorological decision-making.