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AI4Clouds: Enhancing Short-Term Cloud Fields in DestinE for the Solar-Energy Sector

Fernando Iglesias-Suarez[1], Markel García[1], Ignacio Heredia[2], Antonio Perez[1], Sergio Portilla[1], Judith Sáinz-Pardo[2], and Daniel San-Martin Segura[1]

[1]Predictia Intelligent Data Solutions S.L., Santander, Spain (iglesiasf@predictia.es)

[2]Instituto de Fisica de Cantabria, CSIC–Universidad de Cantabria, Santander, Spain

The AI4Clouds project develops a deep-learning-based enhanced short-term (up to 12 h) cloud fields for the Destination Earth (DestinE) Weather-Induced Extremes Digital Twin (Extremes DT). By fusing high-resolution Extremes DT simulations with EUMETSAT satellite observations (SEVIRI / FCI), the system learns to correct systematic model biases and provide enhanced cloud-related fields, such as cloud cover, optical depth, and top height fields, which are key variables for renewable-energy and weather applications.

AI4Clouds follows a multi-stage training strategy: it first pre-trains on ERA5 reanalysis data collocated with satellite datasets to capture large-scale dynamics, then fine-tunes on Extremes DT forecasts, also collocated with satellite datasets. It employs stretched-grid Graph Neural Network–Transformer architectures implemented within ECMWF's Anemoi framework. Probabilistic forecasts are produced via an ensemble approach that quantifies aleatory and epistemic uncertainty. All data retrieval, preprocessing, training, and serving workflows are deployed on the DestinE Data Lake using its HDA, ISLET, and Stack services, ensuring reproducibility and operational integration through MLOps pipelines.

Validation relies on the open-source AQUA framework, extended with cloud-forecast and deep-learning diagnostics (e.g., RMSE, bias, CRPS, spectral metrics). An industrial partner from the solar-energy sector provides user-driven evaluation across several Iberian sites.

By integrating Earth-observation data, high-resolution numerical forecasts, and deep learning within DestinE's infrastructure—a cloud-native environment—AI4Clouds demonstrates a scalable path toward building actionable applications for weather-sensitive sectors.