Objectives

Renewable energy production increased in the past years and will continue rising to serve the ambitious goal of (near) zero fossil fuel energy. Given the weather dependency of renewables any sort of extreme event for the respective power system this poses a threat to grid stability, security, and the whole environment. Planning ahead of taking prevention measures to secure energy supply and serve the energy demand needs knowledge on the possibility of occurrence of meteorologically driven extreme events.

In MEDEA, we tackle this by:

• **Defining and identifying meteorologically driven extreme events** for the renewable (solar, wind) power system. This includes "typical" meteorological events which can pose a threat to the system such as prolonged calm episodes with low stratus clouds resulting in reduced wind and solar energy production.
• **Develop automatic and data-driven methods** for the detection of anomalies and causalities within the weather, climate, and power production data.
• **Improving and developing machine learning forecasting methods** based on the detection methods for prediction of extreme events for the next days ahead.
• **Determine the return period and frequency** of such events using climate simulations.

Results

**Result 1 – WP3 Clustering and anomalies prediction for wind extremes**

Based on a ConvLSTM with adapted weighting of loss function and adapted metric using 10 years of ERA5 data for training. Application to ECMWF IFS forecasts as well as AROME currently in preparation.

**Result 2 – WP4 Granger Causal relationship for storm events**

The method HMML determines Granger causal relationships among $p > 3$ variables using the minimum message length principle (MML) and genetic algorithm for optimization.

\[
\alpha_i \approx \beta \left( \mathbf{X}_i \right)
\]

$x =$ wind speed

$\beta =$ lin function

$K =$ subset of all features

$\beta =$ vector of causal coefficients of target variable $x$.

**Result 3 – WP5 Prediction of meteorologically induced extreme events**

Sequence-to-Sequence LSTM and random forest used to combine WRF, AROME-forecast, and observation for solar power prediction in East Austria during Saharan dust events.

**Result 4 – WP5 Climate indices**

- Sustained drought: creation of a continuous precipitation deficit / warming values based on thresholds were calculated for every Julian day.
- HDD/CDD: calculation of heat days, etc. and relation to HDD/CDD
- Precipitation totals based on OEK515 for RCP2.6, RCP4.5, and RCP8.5

Dissemination and publications

- **EGU 2021**, Petrina Papazek and Irene Schicker: A deep learning LSTM forecasting approach for renewable energy systems.
- **EMS 2020**, Forecasting of Meteorologically Driven "extremes" in Wind and Solar Power: Can We Tackle and Improve Selected Cases of NonForecasted Extreme Events using Deep Learning?; Petrina Papazek, Irene Schicker, and Rosmarie de Wit.

In preparation:


Progress

**Synergies ACRP projects**

- HirMod, ACRP 2009
- PRESENCE, ACRP 2011
- NetZero204
- EXAFOR
- CHANTI

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