Empirical statistical downscaling with EPISODES in an Alpine territory

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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Some basic facts about EPISODES

- **2-stage empirical statistical downscaling** method (analog method as principal method, perfect prognosis ansatz)
- Intention: Ability for downscaling of **climate projections**, but also downscaling of **decadal** and **(sub-)seasonal predictions**
- Meets requirements of climate impact community: Generation of **consistent multivariate**, **multi-site** time series consisting on **daily values** for several surface target variables (T, Tmin, Tmax, Prec, Hum, Wind…)
- **Advantage: Low computational costs** compared to dynamical downscaling.
- **Preconditions**: Long-term consistent observation data set of target variables to represent the past climate, resolution of observations determine possible target resolution.
- **Developed** at German national weather service, DWD (Kreienkamp et al., 2019)*, 2020 set-up and further development at national weather service in Austria (ZAMG)

*Kreienkamp, F., Paxian, A., Früh, B., Lorenz, P., Matulla, C.: Evaluation of the empirical–statistical downscaling method EPISODES. *Clim Dyn* **52,** 991–1026 (2019). https://doi.org/10.1007/s00382-018-4276-2

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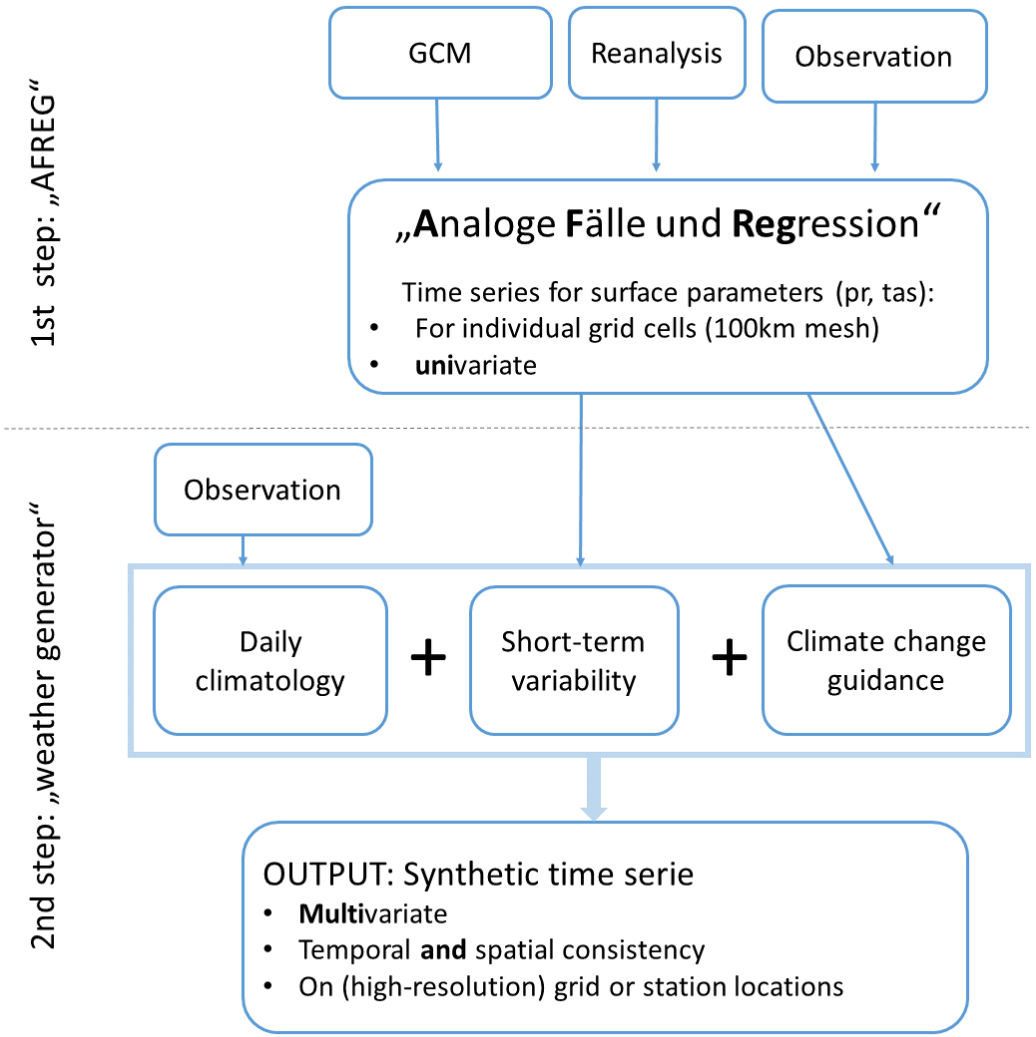
The EPISODES method in a nutshell



Derive daily target values for each 100km-cell from linear regression of x analog days.

GCM as driver of climate change guidance: low-pass filter of anomalies

High-res observations provide local patterns and climatology

Short-term variability: Matching Obs. and AFREG short term anomalies & select most similar day for all parameters and whole target region

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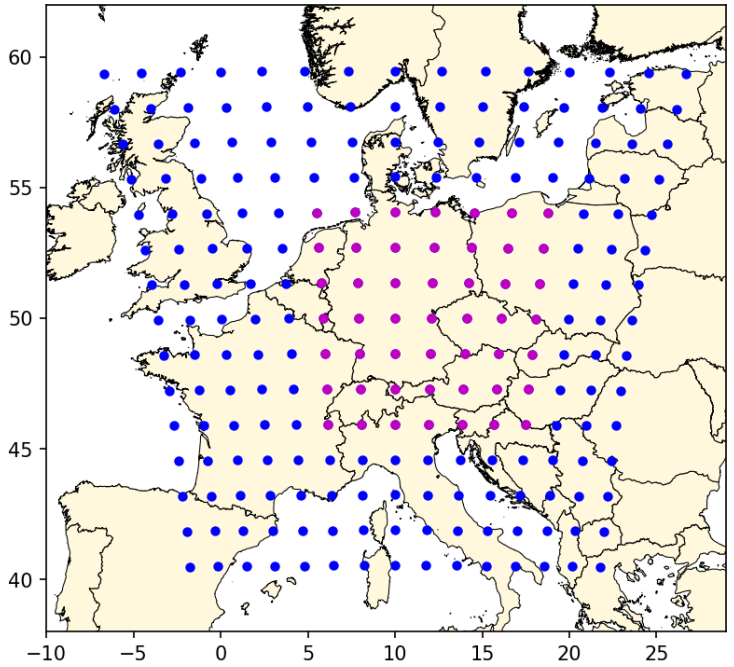
First experiences with EPISODES in Austria

- 2020: Downscaling of a test ensemble of 6 selected GCMs (CMIP5/rcp85) to 1km resolution for mean daily temperature and precipitation.
- Reference: SPARTACUS observation data set.
- Version **EPISODES2018:**
  - Unique variables for analog days and regression:

Analog days	Precipitation: Vorticity 850 hPa & horizontal Geopot. Diff. North-South 700 hPa Temperature: Geopot. 500 hPa & Rel.Top. 1000-850hPa
Regression	Precipitation: Relative Humidity 850 hPa Temperature: Daily Air temperature 1000 hPa

  - Unique set of precipitation classes for correction
  - Focus on all processed cells for selection of best matching day.



Equidistant 100 km grid (blue) with processed cells (purple)

Results are promising, esp. for annual values. **BUT**: Results for Austria are inferior to Germany, due to topographic influences. Larger seasonal biases detected for precipitation.

Steps towards regionalization: Focus on analog and regression for precipitation.

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Selection of regionalized selector & predictor variables

Parameters	Levels Selector	Levels Predictor
mean Daily Geopotential height	850 hPa 700 hPa 500 hPa	1000 hPa 850 hPa
mean Daily Air temperature	850 hPa 700 hPa 500 hPa	1000 hPa 850 hPa
mean Daily relative humidity	850 hPa 700 hPa	1000 hPa 850 hPa
Vorticity	1000 hPa 850 hPa 700 hPa	1000 hPa 850 hPa
horizontal Differences East-West	850 hPa 700 hPa	850 hPa
horizontal Differences North-South	850 hPa 700 hPa	850 hPa
Relative Topography	1000-850 hPa 1000-700 hPa 850-700 hPa	1000-850 hPa 1000-700 hPa 850-700 hPa
Advection of. Temperature	850 hPa 700 hPa 500 hPa	850 hPa
Advection of spec. humidity	850 hPa 700 hPa	850 hPa 700 hPa

- AFREG tested for a large combination of variables on different vertical levels.
- For each (100 km) grid cell, season & target parameter
- 2 selector (selection of analogues) + 1 predictor (regression) variable for each selection
- Metrics: Bias*, RMSE*, MAE*, Pearson Corr., Kolmogorov-Smirnov-Test (* also for 1d-persistence)
- **Result:** „Top-List“ of parameter sets by combining different metrics and years.

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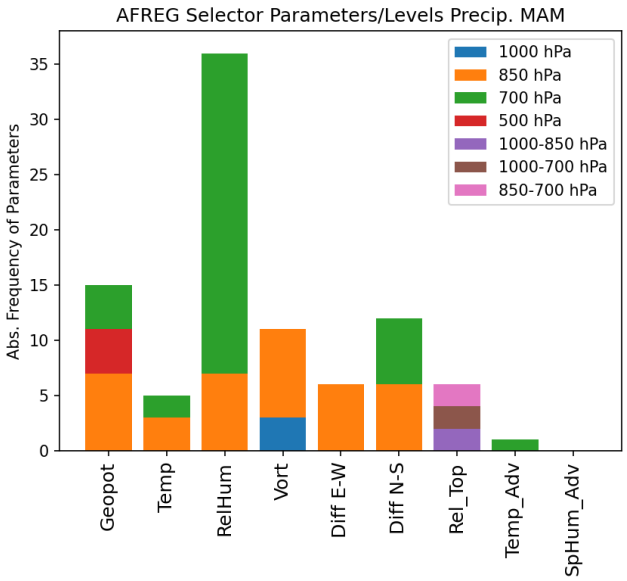
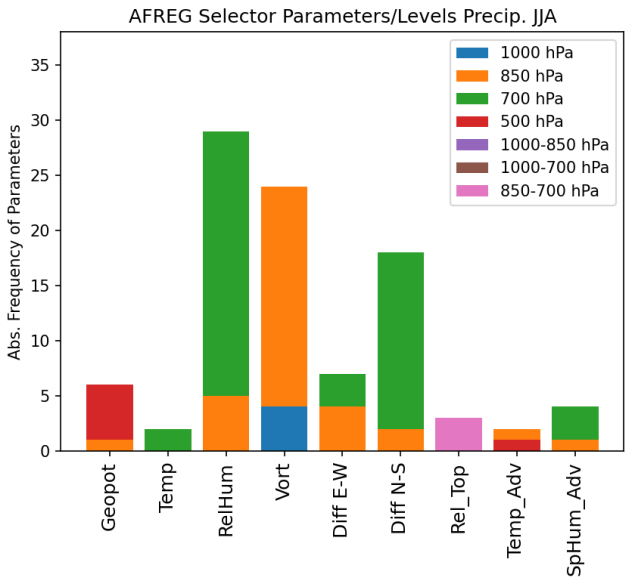
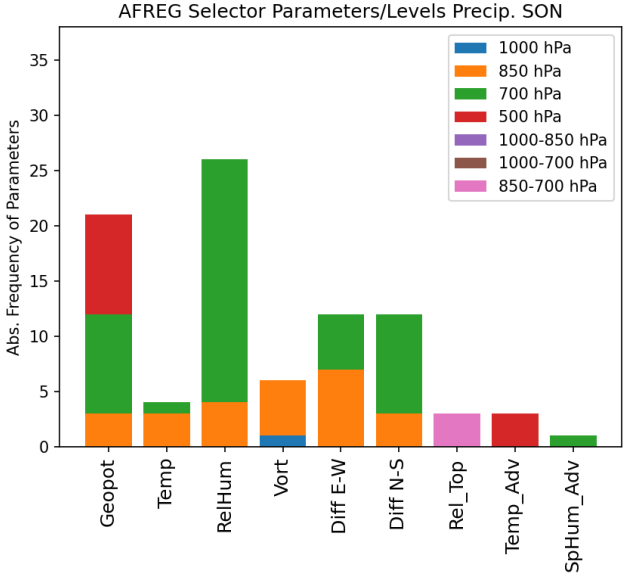
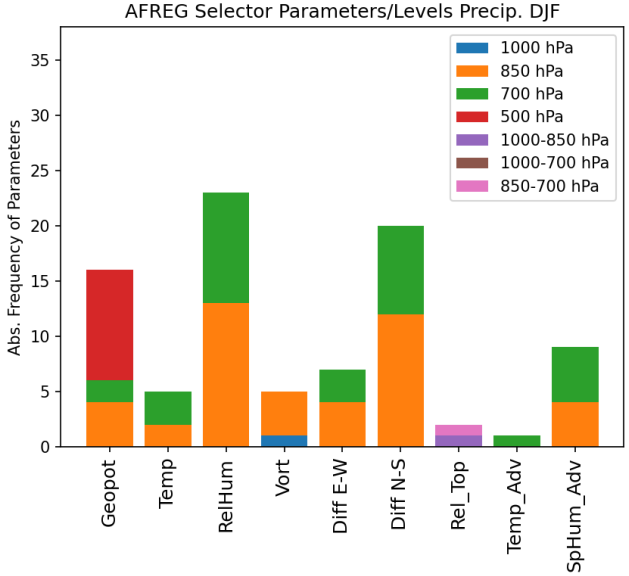
Preferred Selectors for analog days - Precipitation









Selection of **2** parameters per grid cell!

Most frequent combinations:

MAM:
Rel.Hum 700 hPa &
Geopot. 850 hPa (5)

JJA:
Horiz. Diff. North-South 700 hPa & Vorticity 850 hPa (15)

SON:
Rel. Hum 700 hPa &
Horiz. Diff. East-West 700hPa (5)

DJF:
Geopotential height 500 hPa & rel. Hum 850 hPa (6)

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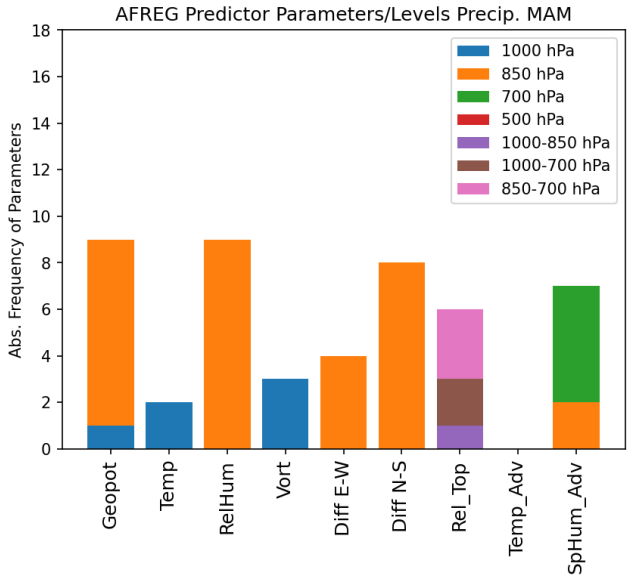
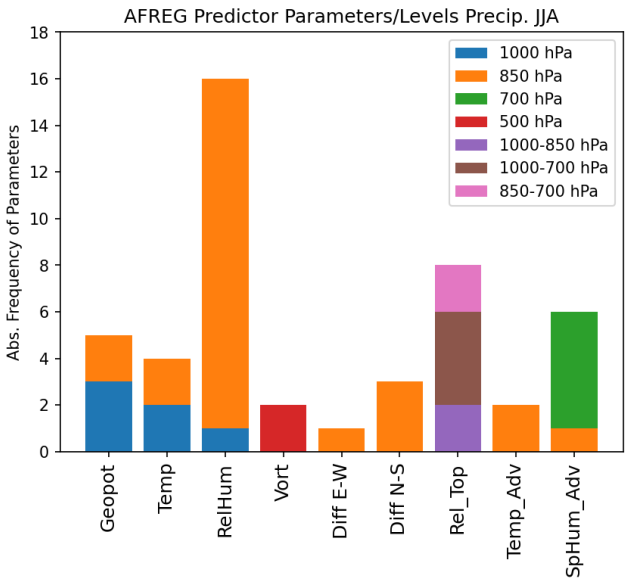
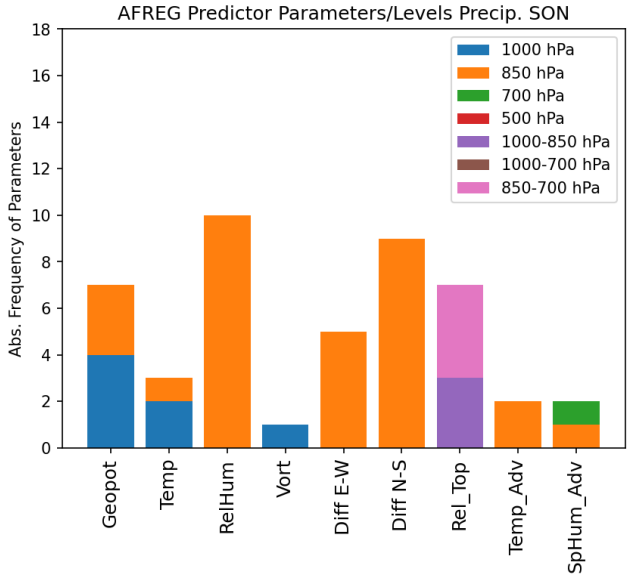
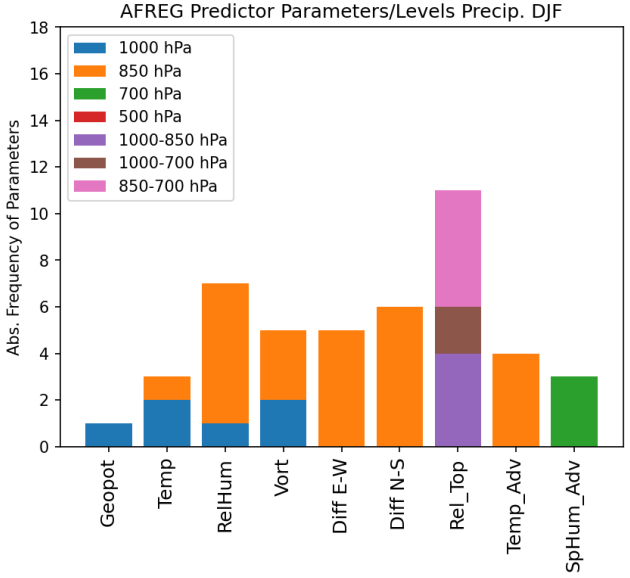
Preferred Predictors per season - Precipitation









Predictor variables for linear regression.

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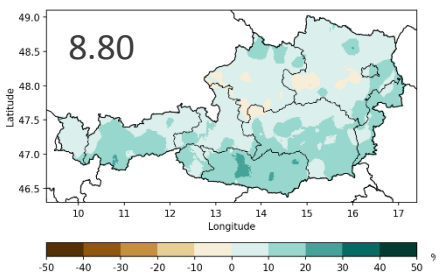
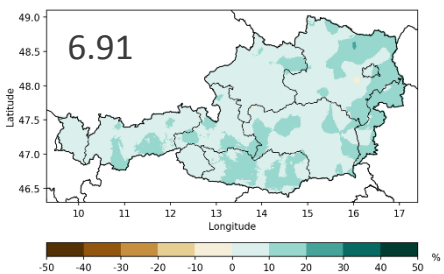
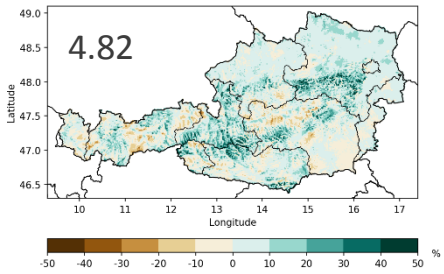
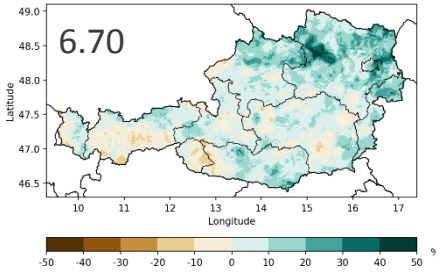
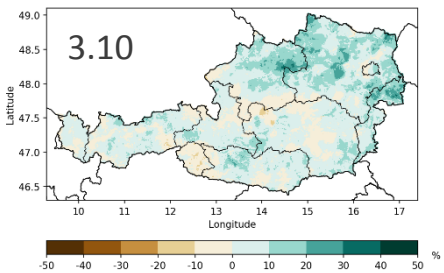
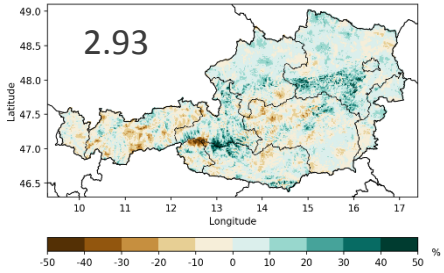
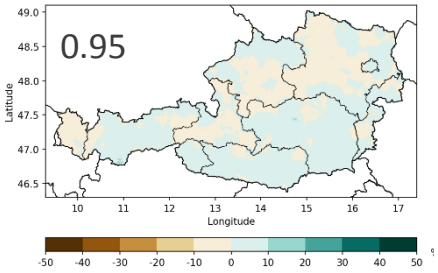
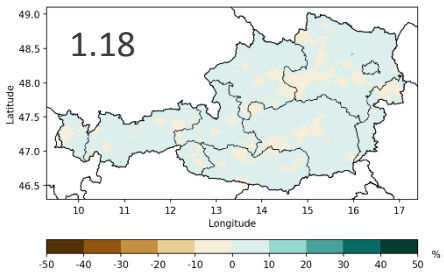
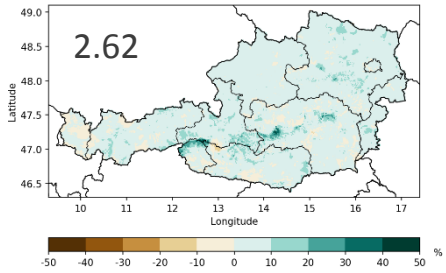
Validation Results with regionalized AFREG – Annual Precipitation

Comparison with SPARTACUS 1971-2000

	EPISODES2018 MPI-ESM-LR r1	**EPISODES REG-AFREG** MPI-ESM-LR r1	**ÖKS15** MPI-ESM-LR r1 – CCLM4-8-17
Relative diff. of mean annual precip.			
Rel. Diff. of 99th pctl			
Rel. Diff of Wet Day Frequency			

Annual results could be improved (lower bias for annual precipitation sums & for 99th percentiles). Very good performance for wet day frequency!

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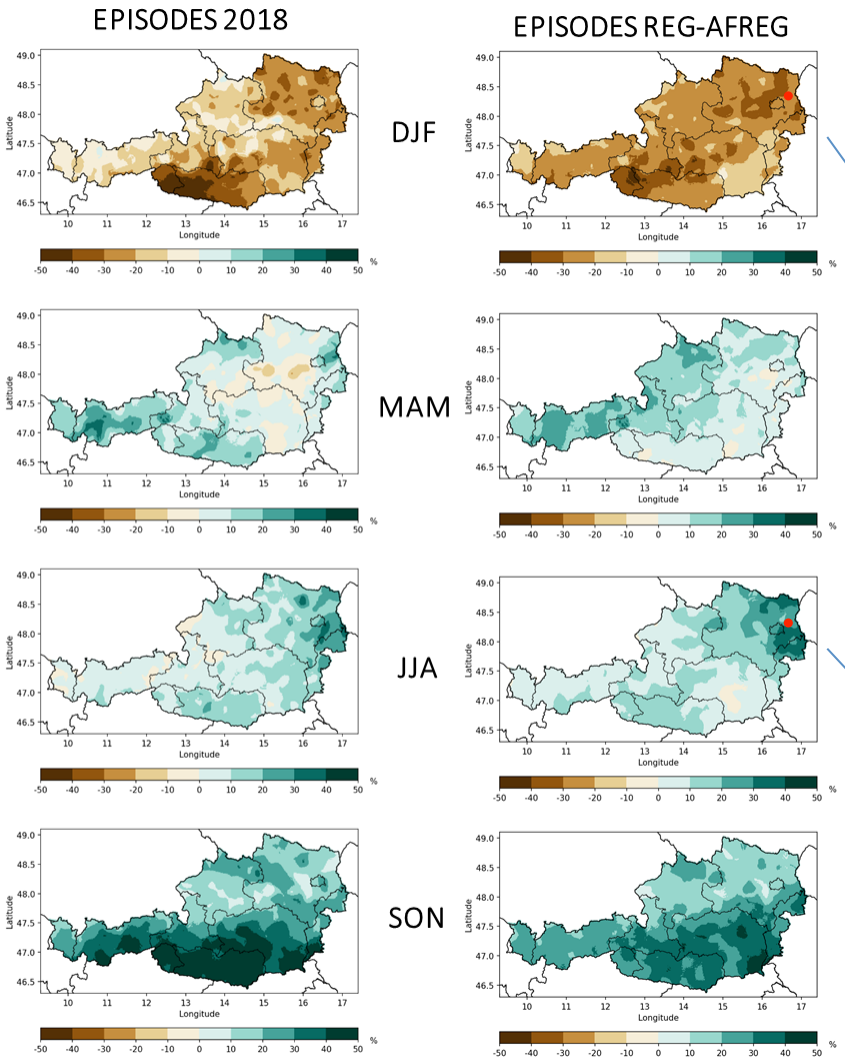
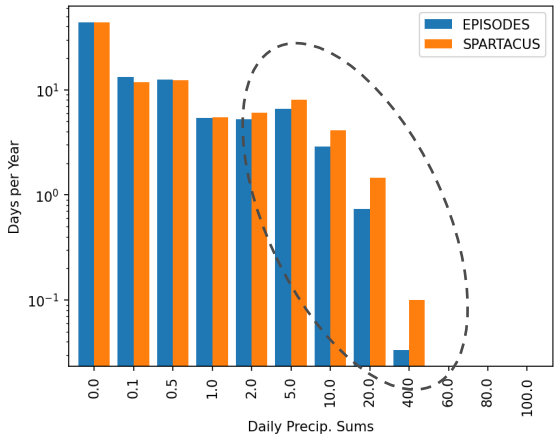
Results for regionalized AFREG – Seasonal Precipitation

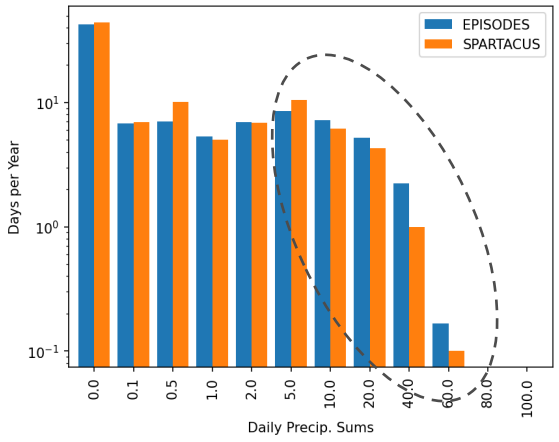


Relative diff. of mean seasonal precipitation

Annual performance for the past is promising! BUT: Regionally large biases for seasonal precipitation.



DJF:
Underestimation of larger precipitation sums



JJA:
Overestimation of larger precipitation sums

Seasonal distribution of 20 km x 20 km north-east of Vienna (flat land)

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Lessons learned and further steps to go

- Regionalization of EPISODES first stage, AFREG, could provide some improvement in terms of annual results
- No improvement in seasonal results for precipitation. For other parameters like temperature seasonal deviations are very small.
- AFREG step does not cause the seasonal deviations for precipitation
- Further focus on weather generator (2nd stage of EPISODES):
  - Daily precipitation values divided into fixed classes
  - Correction of classes on annual basis

  → Search for more dynamic solution!

Further targets:

- Generate predictions and projections as alternative to dynamical methods
- Continue work for increased robustness and reliability

Thank you for your interest!

This presentation gives you insight in our ongoing research.

Your comments and questions are welcome!

Contact: Theresa.schellander-gorgas@zamg.ac.at

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