1. Motivation and Objectives

- Large scale circulation patterns have long been associated with local weather conditions (i.e. rain!)
- Obs. rainfall time series often too short/incomplete
- Need for stochastic simulation
- Conditioning of a stochastic precipitation model should hopefully improve its ability to better reproduce observed rainfall, especially extremes
- Can other atm. variables improve CP classification?
- Conditioning allows synthesis of future climates

2. Study Area and Data

**Observed Rainfall (German Weather Service DWD):**

- 1 minute temporal resolution, aggregated to 1hr
- Rainfall gauges in/near German federal state of Lower Saxony (Figure 1)
- Continuous observations between 1996-2016

**Atmospheric data (NCEP-DOE Reanalysis 2):**

- 1979 onwards, 2.5 degree grid coverage, daily
- Geopotential heights: 500hPa, 850hPa, 1000hPa
  - Spatial scale: 35°N to 65°N, 30°W to 45°E
  - Anomalous: $A(i,t) = (P_i - P_{min,t}) / (P_{max,t} - P_{min,t})$
  - PCA transformed to 14 principal components, explaining >95% variance

- Regional climate variables (extent: Lower Saxony)
  - 2m daily temp. / seasonal temp. anomaly
  - 10m V-wind, U-wind
  - Daily max convective available potential energy
  - 2m specific humidity
  - Relative humidity at selected pressure level
  - Precipitable water
- All fields PCA transformed, scaled and centered

3. Methodology

**A: Stochastic Precipitation Model (hourly timestep)**

- **Alternating Renewal Model** (Callau, Haberlandt 2017)
- Model describes rainfall as series of independent wet and dry spells.
- External structure: wet spell amount/duration, dry spell duration
- Internal structure: distribution of rainfall within wet spell

**B: CP Classification (daily timestep)**

- **Automated objective fuzzy based** classification (Bardossy et al. 2002)
- Simulated annealing (SA) optimisation to assign ‘best’ fuzzy rules
- A fuzzy rule is a set of membership functions, which describes the state of each input variable: very low, low, high, very high, not relevant
- The SA objective function favours divergent CPs (wetter/drier)
- The fuzzy rule with the highest degree of fulfilment is chosen as the CP
- **Trialed CP counts:** 4, 6, 8, 10
- CP synthesis for use by precipitation model via first order Markov chain

4. Results and Discussion

- Lower CP counts generally better: shown here N=4, 1000hPa geopotential height
- Wetness indexes (Fig. 3) between calib. & valid. periods stable
- Performance of extremes assessed using an IDF test statistic comparing 50×20 years simulated time series against obs. (20 years) for CP and simpler classifications (Fig. 4)
- Overall performance is poorer for most rainfall event variables (Table 1)

<table>
<thead>
<tr>
<th>Wet Spell</th>
<th>Dry Spell</th>
<th>Wet Spell</th>
<th>Wet Spell</th>
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</thead>
<tbody>
<tr>
<td>Volume</td>
<td>Duration</td>
<td>Volume</td>
<td>Duration</td>
</tr>
<tr>
<td>4 Seasons</td>
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<td>0.40</td>
<td>3.72</td>
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<tr>
<td>2 Seasons</td>
<td>0.44</td>
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<td>2.31</td>
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<td>Fuzzy Method</td>
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<td>3.73</td>
</tr>
</tbody>
</table>

5. Conclusions and Outlook

- Addition of further atmospheric variables led to more robust and varied CPs (wetter and drier)
- Generally better representation of extreme events
- Overall precipitation model performance declined
- Issues due to a mismatch in the temporal resolution between CPs (daily) and precipitation events (hourly, arbitrary lengths)

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**References:**


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