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Session HS7.4
Hydroclimatic change and unchange: exploring the mysteries of variability, nature and human impact

Rainfall trends in hindsight and in foresight

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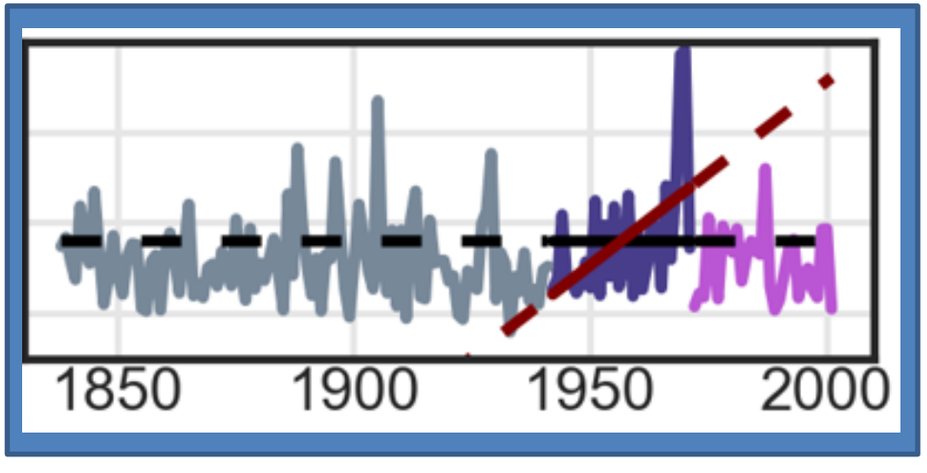

"A trend is a trend is a trend
But the question is, will it bend?
Will it alter its course
Through some unforeseen force
And come to a premature end?"
Sir Alec Cairncross (1969), signing as "Stein Age Forecaster"

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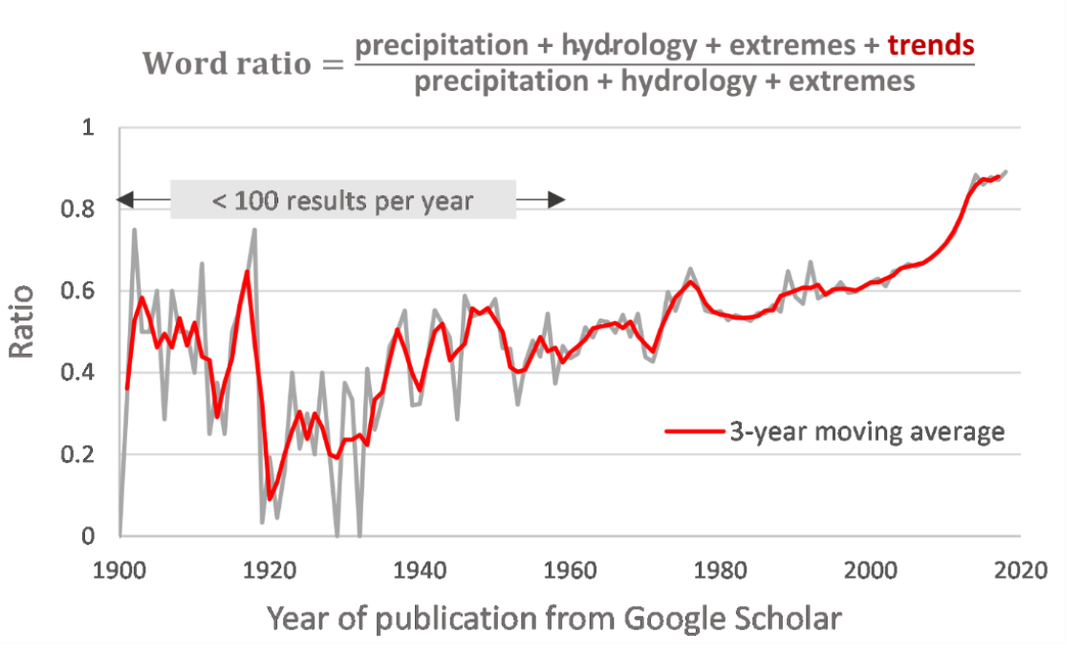
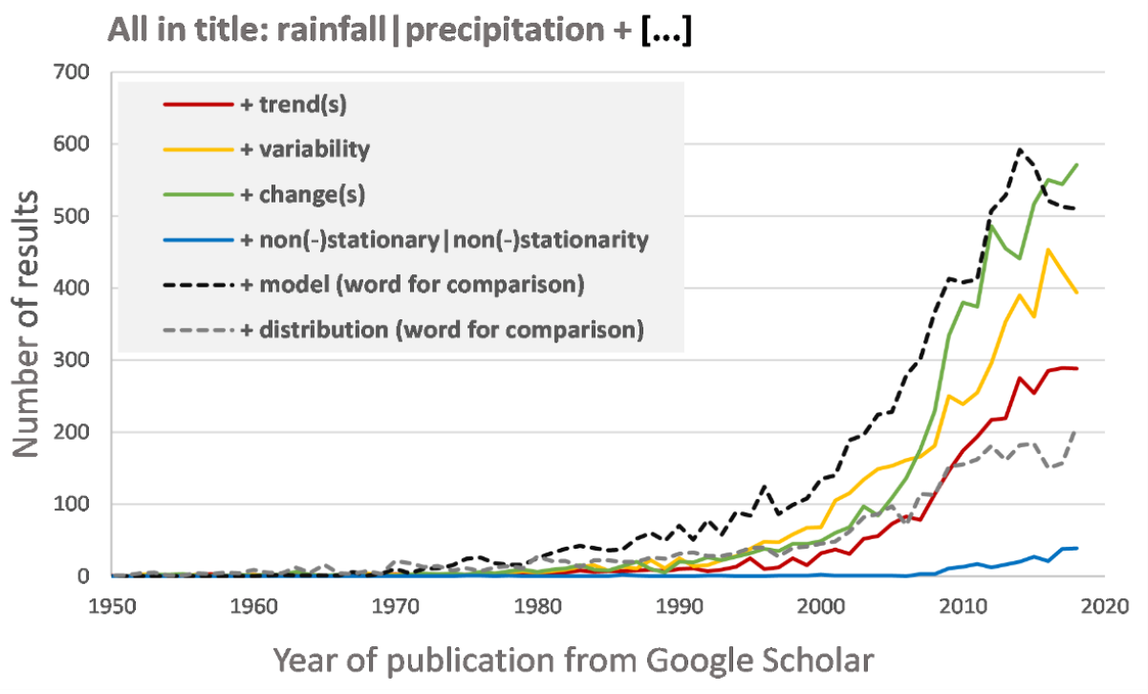
Motivation: the increasing interest in rainfall trends



- From the 1960 and thereafter, the ratio of appearance of the word 'trends' in publications containing the complete list of words ['precipitation', 'hydrology', 'extremes'] has been rising, reaching 89% in 2018.



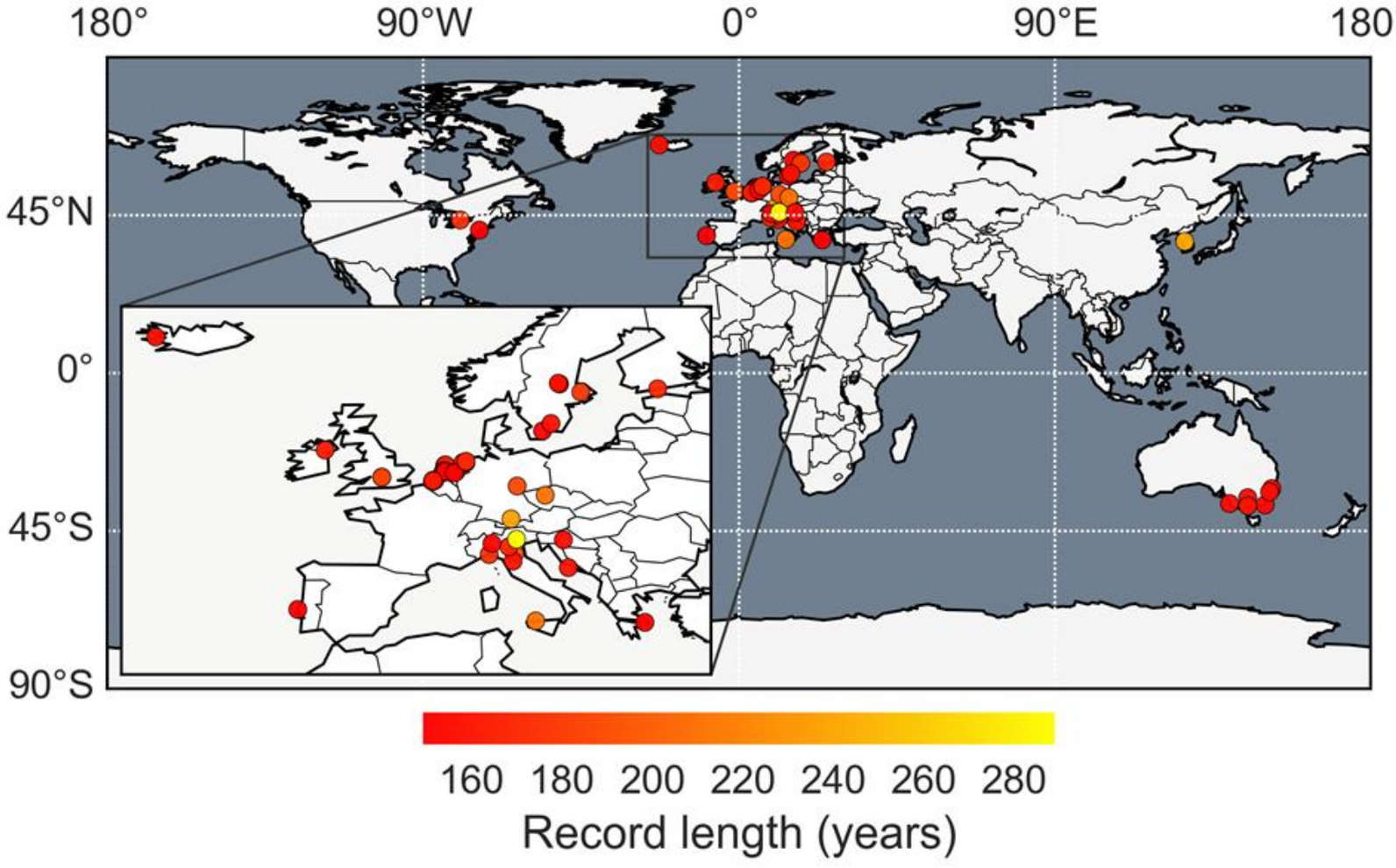
- The explicit in-title use of the word 'trend(s)' along with 'rainfall|precipitation" yields consistently over the last ten years above 200 results per year (288 in 2018, as per results appearing on Google Scholar on 21/10/2019). Terms related to non-stationarity are slowly rising over the past ten years (39 in-title results in 2018), while being close to zero before 2000.

Premises and research questions

- Avoid hypothesis testing and explanatory analysis of past rainfall trends
- Instead provide a prediction-oriented evaluation of rainfall trends to answer the following questions:
  - how well are the rainfall statistics, i.e. annual maxima, annual totals, wet-day average, probability dry, of the most recent climatic period predicted by linear trends calibrated on the prior 30 year period?
  - what is the historic predictive skill (estimated from the whole record) of linear trends and how does it compare to the skill of the simple mean model?

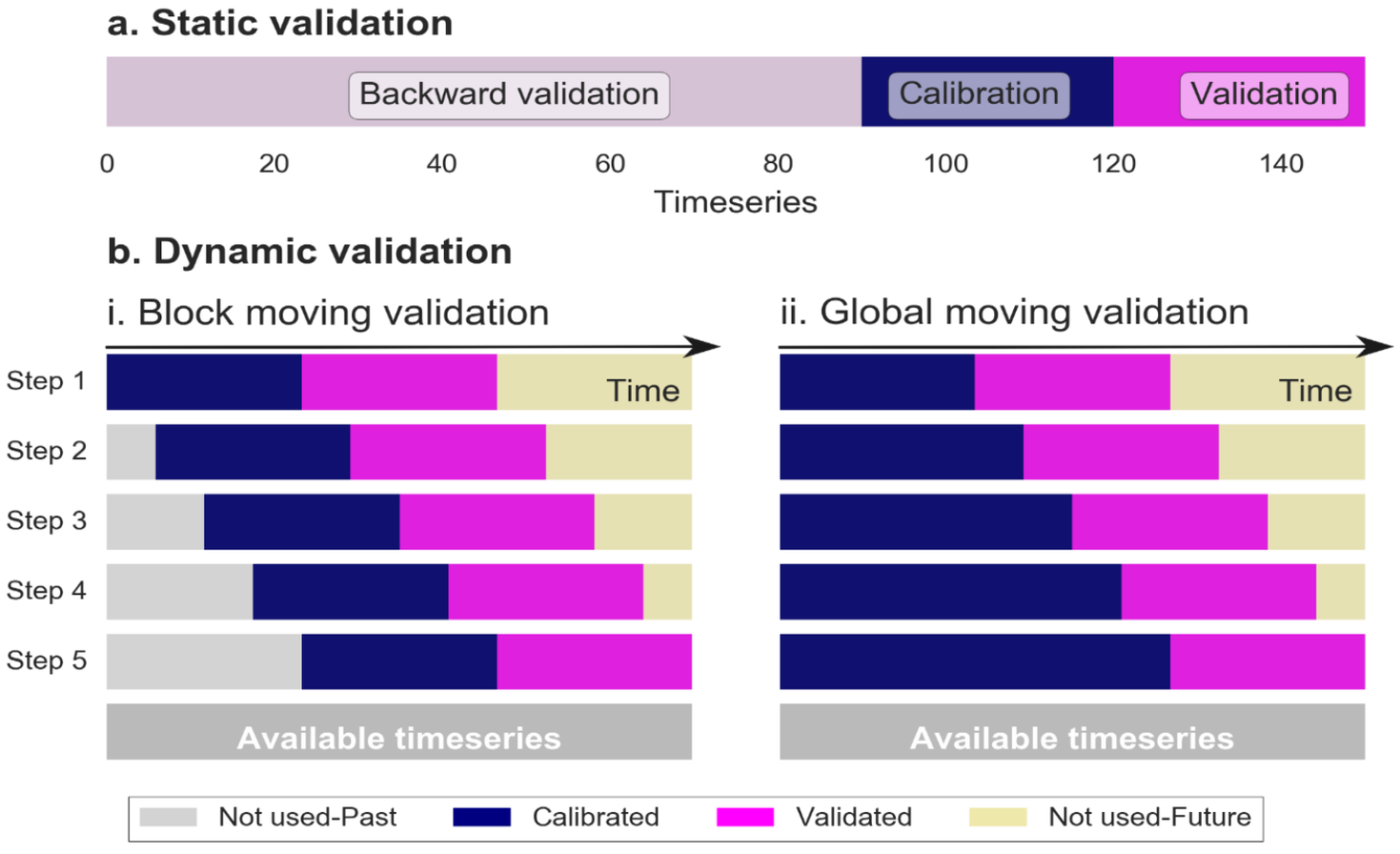
Dataset

- A unique dataset of 60 daily rainfall stations with more than 150 years
- Collected from global databases (NOAA, ECA) and via personal contact



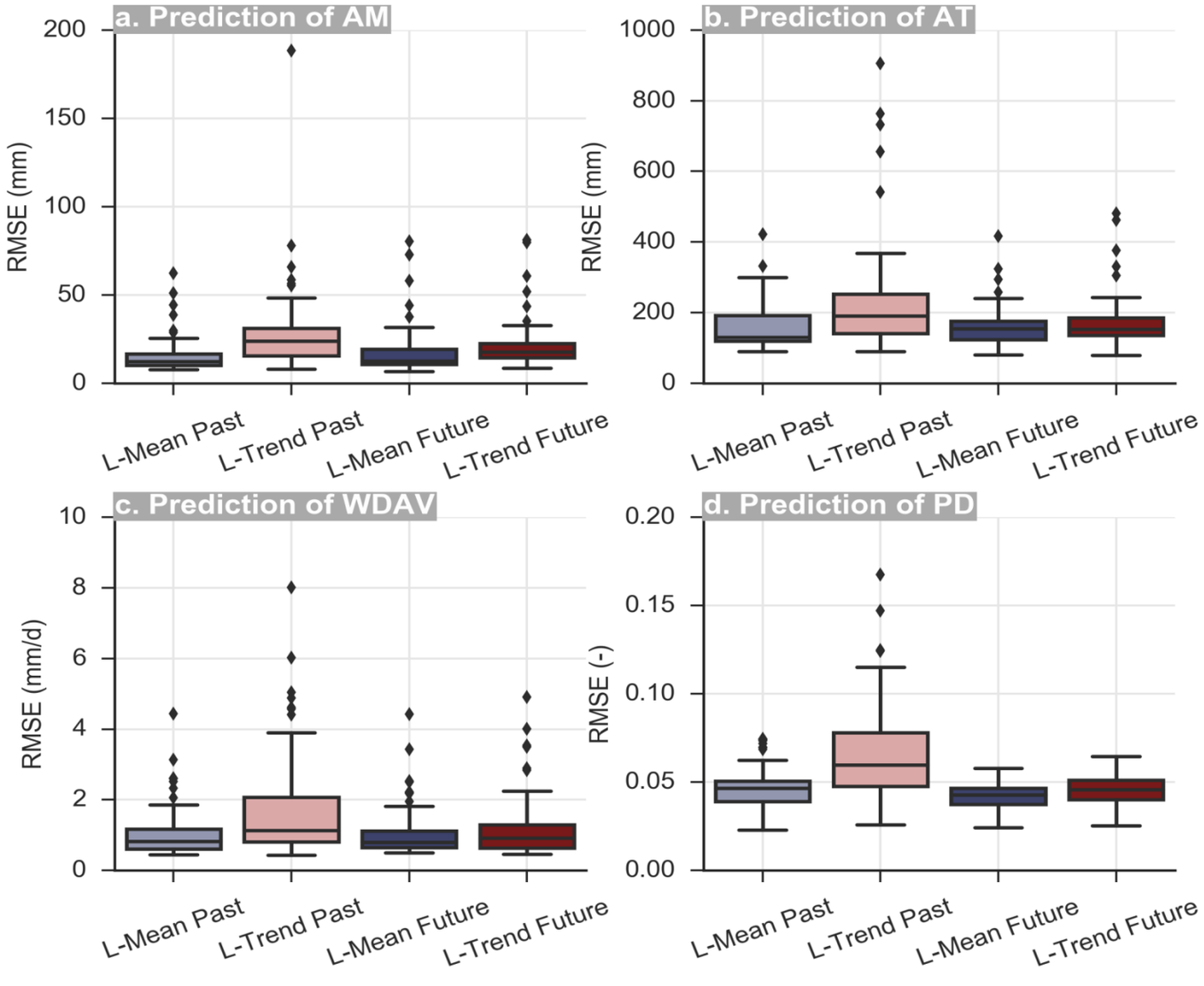
Predictive models and calibration-validation schemes

- Two validation schemes:



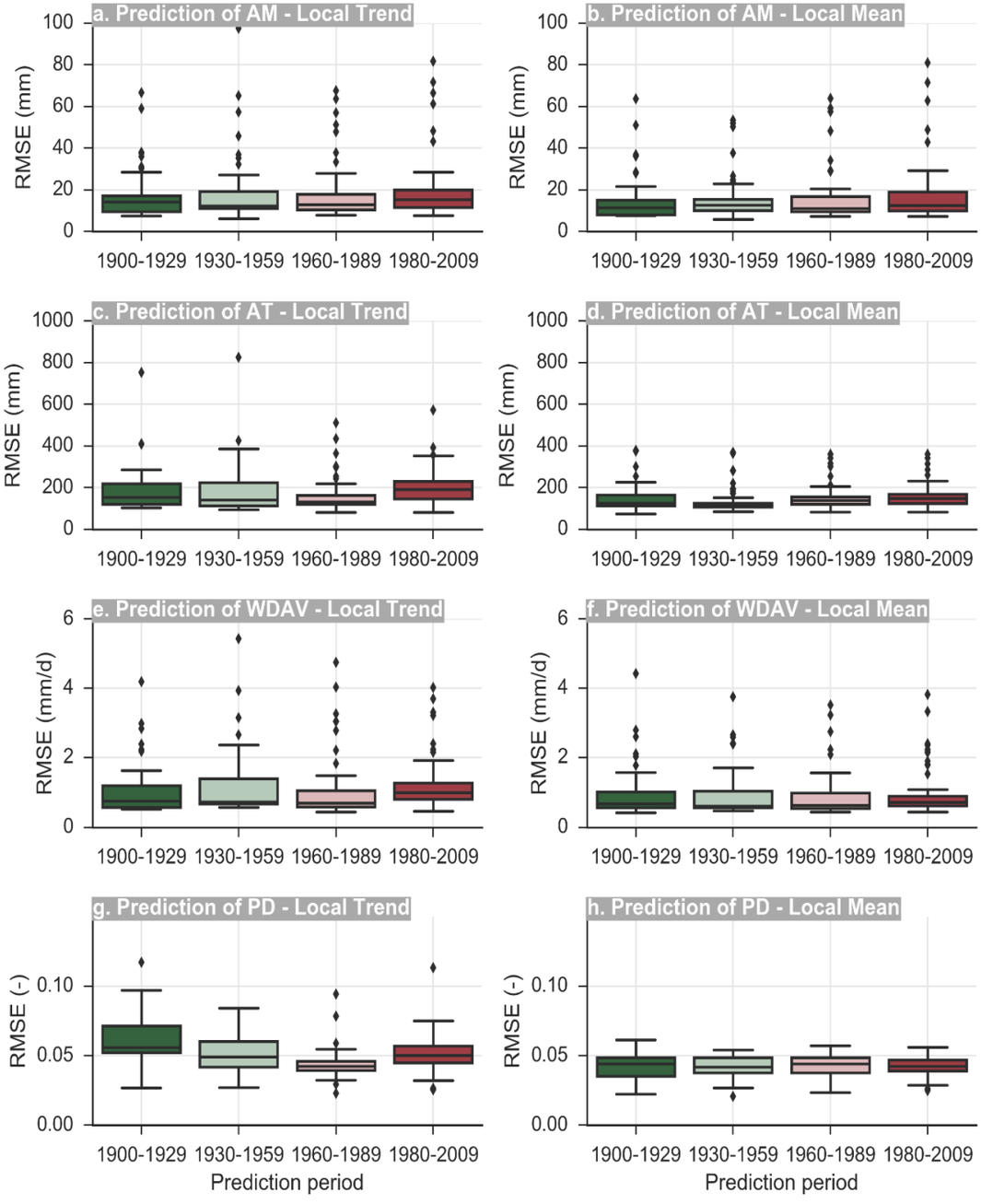
- Four models:
  - **Local models:** Local Trend (L-Trend) and Local Mean (L-Mean)
    - calibrated on the period [$i - 59, i - 30$] and validated on the period [$i - 29, i$]
  - **Global models:** Global Trend (G-Trend) and Global Mean (G-Mean)
    - calibrated on the period [1, $i - 30$] and validated on the period [$i - 29, i$]

Static validation-Backward and Forward



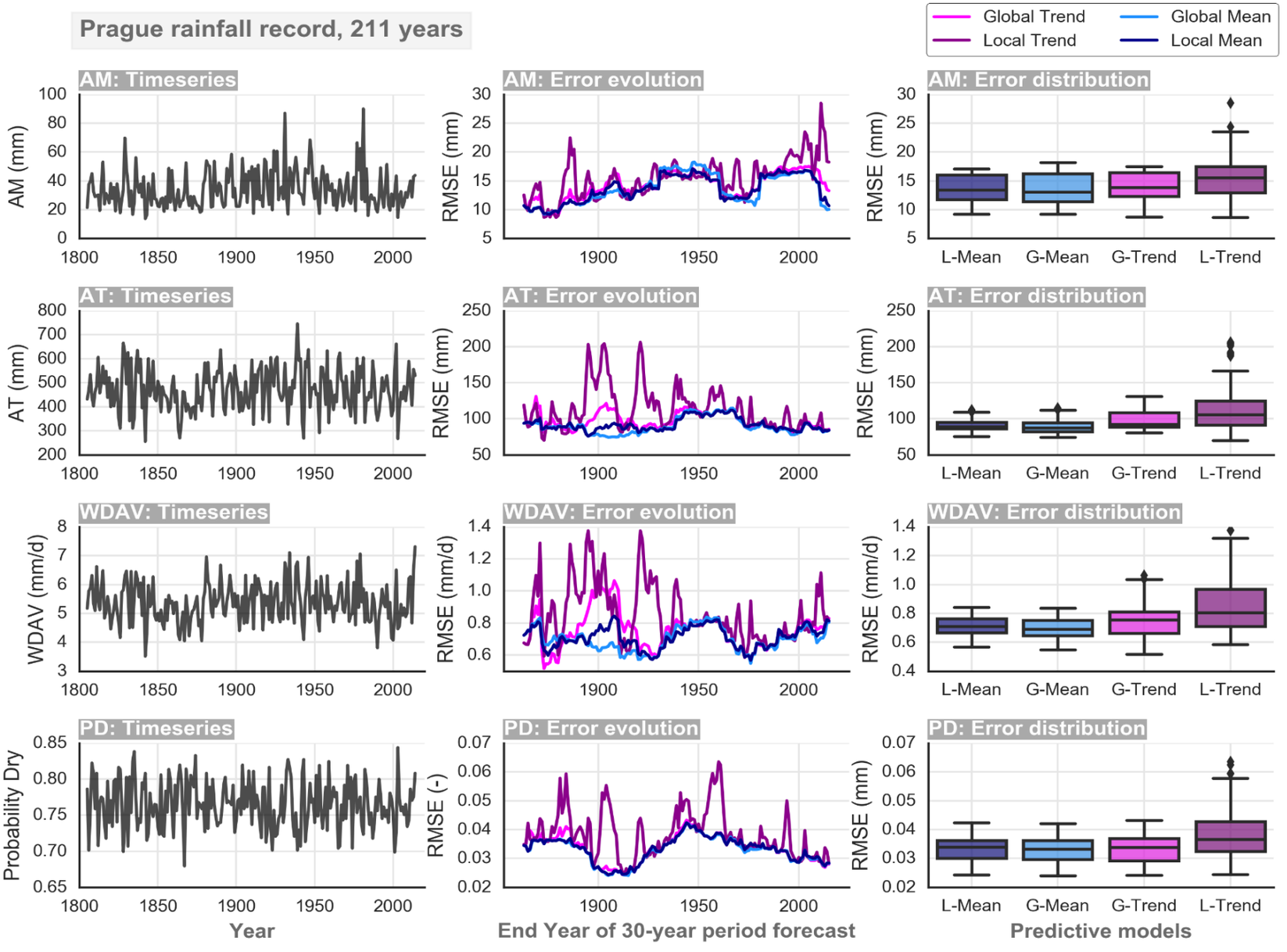
- The L-Mean model performs on average better than the L-Trend model for all indices in capturing their most recent changes of extremes.
- The performance of the L-Trend deteriorates considerably with respect to hindcasting the past.

Static validation-Comparison of past periods

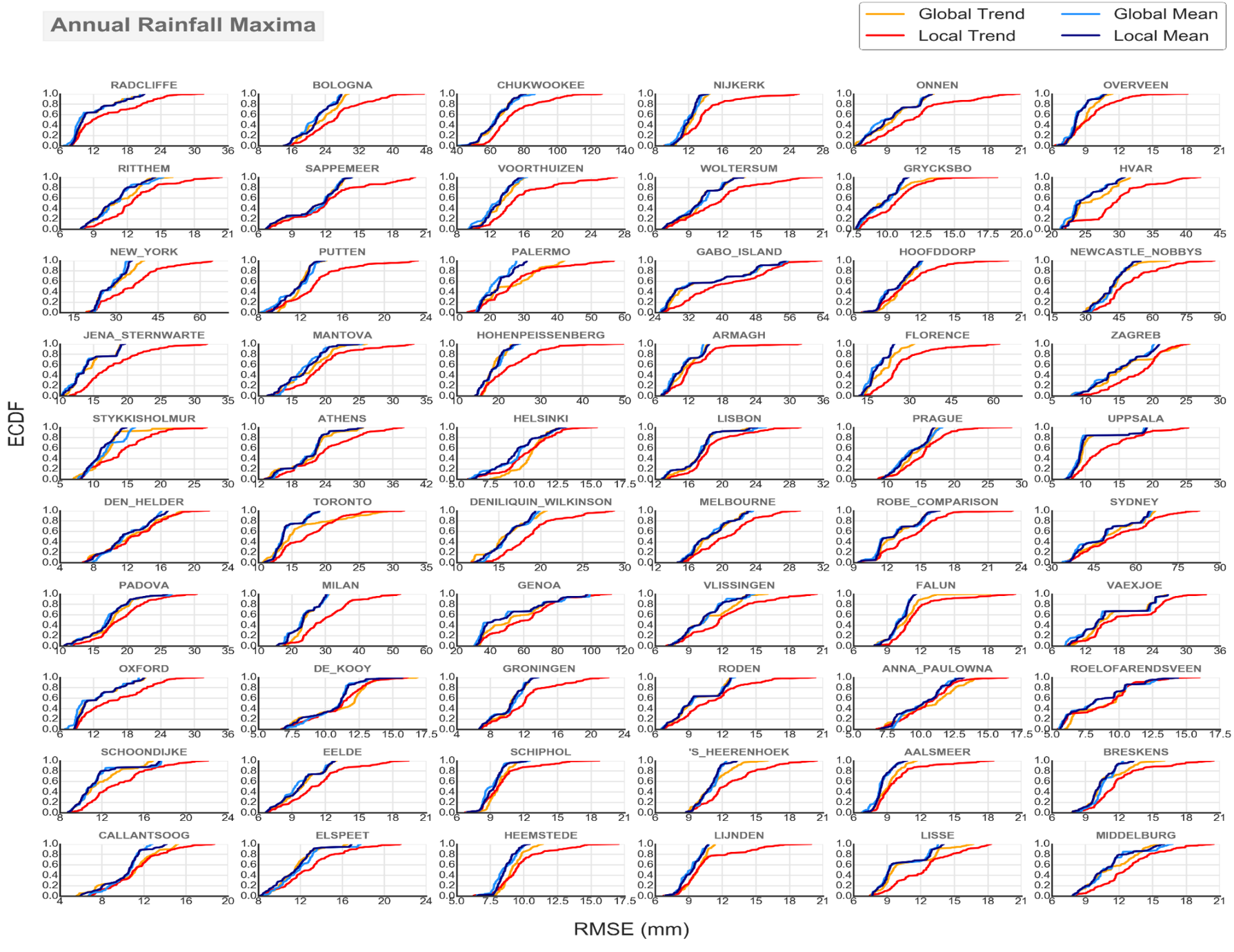


- It is observed that the error distribution of the L-Trend model does not present pronounced temporal differences for the indices among these periods, with the exception of PD which shows a larger, yet not consistent, variability over these periods.
- Among the four periods, the L-Trend model performed best in the prediction of the 1960–1989 period, based on calibration on 1930–1959, a period which however does not include the decades of pronounced increase in greenhouse emissions (from the 60s and thereafter).
- The predictive performance of trends on the latest period is not markedly different from the previous periods, if not it is slightly worse for some indices, e.g. the AT.
- A particular pattern is neither observed for the L-Mean.

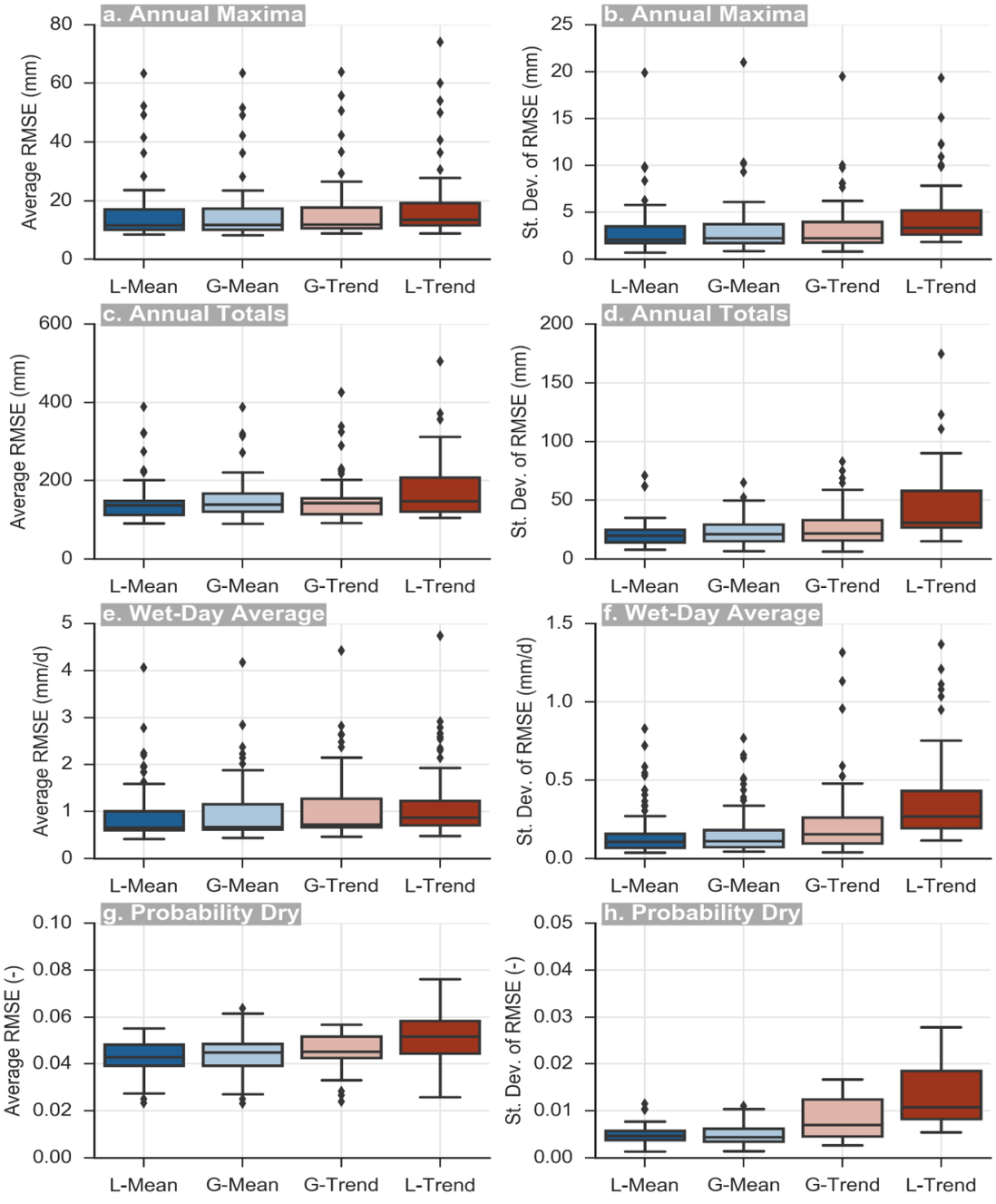
Dynamic validation – An example application for Prague



Dynamic validation – ECDF of annual maxima prediction errors



Dynamic validation – Summary statistics of all indices

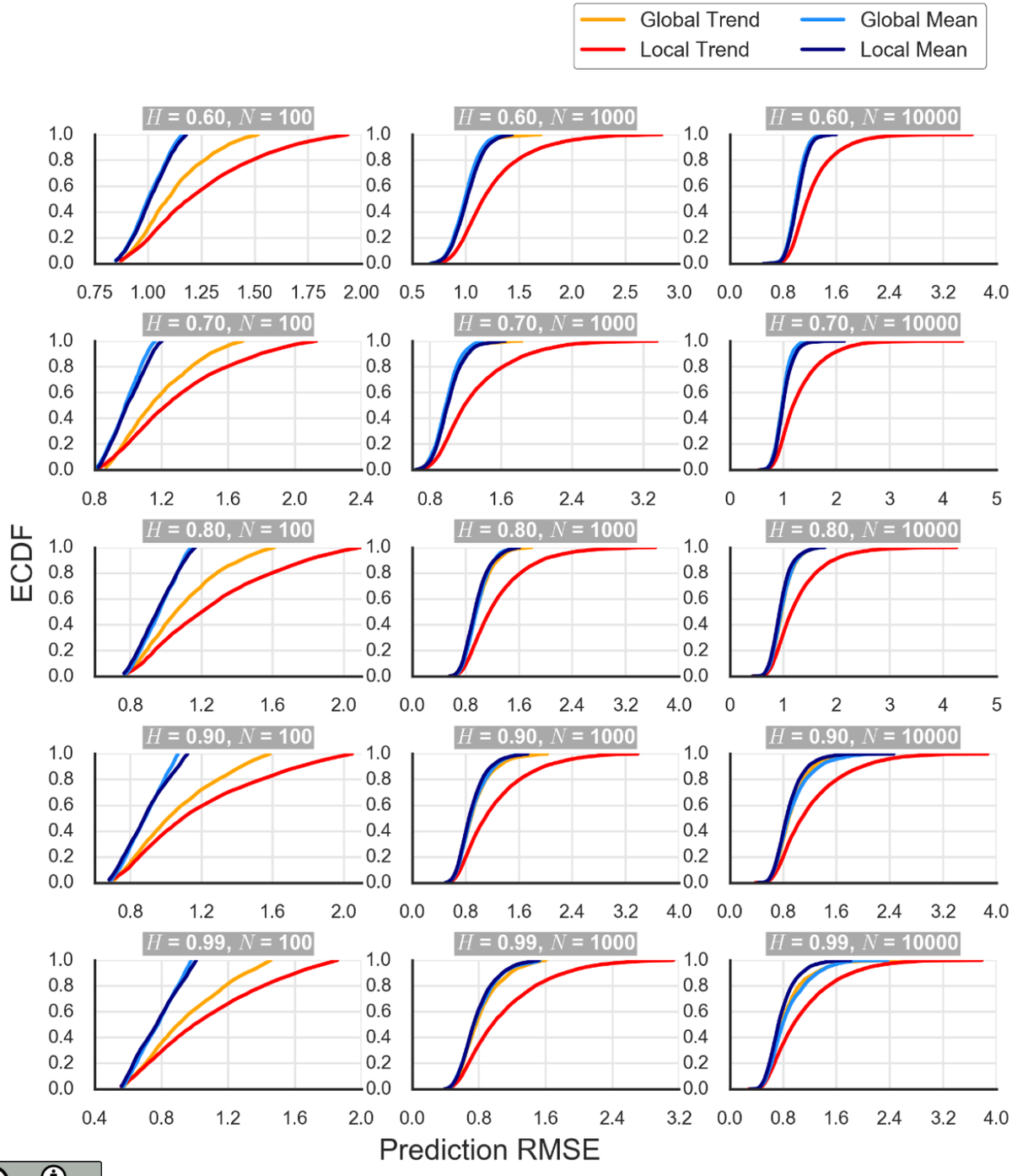


- The models' performance can be ranked from best to worse as follows: (1) L-Mean
  (2) G-Mean
  (3) G-Trend
  (4) L-Trend

- The L-Mean model marginally outperforms the G-Mean with respect to the average RMSE, yet in terms of the standard deviation of the RMSE distribution, the L-Mean model has smaller standard deviation of prediction errors, and thus more reliable performance.

- The linear trend model shows markedly inferior performance.

Models' performance under persistence



- The goal is to test the performance of the predictive models in conditions of enhanced structured uncertainty, characterized by changes at all scales and 'trend-like' behaviour for small periods, as in persistent processes (Koutsoyiannis, 2002).
- The behavior observed in the *N*=100 plots is qualitatively consistent with the one observed from the rainfall records.

Conclusions

- Future rainfall variability is on average better predicted by mean models, as local trend models identify features of the process that are unlikely to survive the end of the calibration sample, either being extreme observations, or ‘trend-like’ behaviour.
- This empirical finding suggests that the large inherent variability present in the rainfall process makes the practice of extrapolating local features in the long-term future dubious, especially when the complexity of the latter increases.
- Prediction-wise, it is shown that simple is preferable to trendy.

References

- Cairncross, A., 1969. Economic forecasting. The Economic Journal 79, 797–812.
- Koutsoyiannis, D., 2002. The Hurst phenomenon and fractional Gaussian noise made easy. Hydrological Sciences Journal 47, 573–595.

Further reading: Iliopoulou, T., Koutsoyiannis, D., 2020. Projecting the future of rainfall extremes: better classic than trendy, Journal of Hydrology, in press, https://doi.org/10.1016/j.jhydrol.2020.125005

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