Probabilistic Forecasts using Analogs in the Idealized Lorenz96 Setting

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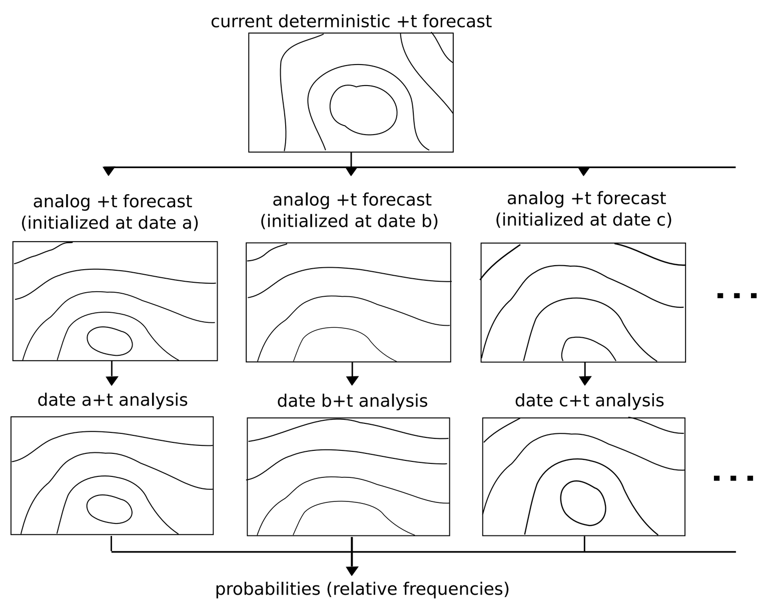
INTRODUCTION

Human forecasters often use memories of past weather situations to calibrate actual weather forecasts.
Analog methods try to automatize this approach and can also predict uncertainties.
In this study we test two analog approaches in the Lorenz96 model, a simple model to simulate the chaotic behaviour of the atmosphere.
These two analog approaches are compared to direct model output of an ensemble forecast and logistic regression which has been shown to be one of the best methods to calibrate ensemble forecasts (Wilks, 2006; Wilks and Hamill, 2007).

ANALOG METHOD

Idea: Search for similar patterns of a current NWP forecast in an archive of past forecasts.
If several similar forecasts are found, take the ensemble of corresponding observations (analyses) for prediction.



Two methods:

- **adf**: find analogs of a deterministic forecast (see Figure above).
- **analog dressing**: find analogs of each member of an ensemble of model forecasts ⟶ form a larger ensemble.

Analog criterion: two situations are similar if the sum of squared differences over several grid points is small.

DATA–THE LORENZ96 MODEL

Instead of testing the analog methods with real weather data we use the Lorenz96 model as idealization of weather and weather forecasts. With such a model, statistical concepts can be tested relatively simply and inexpensively. Different to real weather the "true" state of the system is known exactly.

The Lorenz96 model (Lorenz, 1996) is an extension of the well known Lorenz63 model (Lorenz, 1963; Lorenz attractor) to simulate the chaotic behaviour of the atmosphere.
It consists of a set of differential equations with a set of a large scale quantity that is connected to faster, smaller-scale parameters (see Figure above).

- Beside the computation of a "true" state, forecasts are simulated by parameterizing the smaller scale process.
- Perturbations of the "true" state are used to initialize several ensemble members.

⟶ thus a series of forecast verification pairs are computed that offer a testbed for ensemble model output statistics (ensemble MOS) methods (Wilks, 2006).

RESULTS

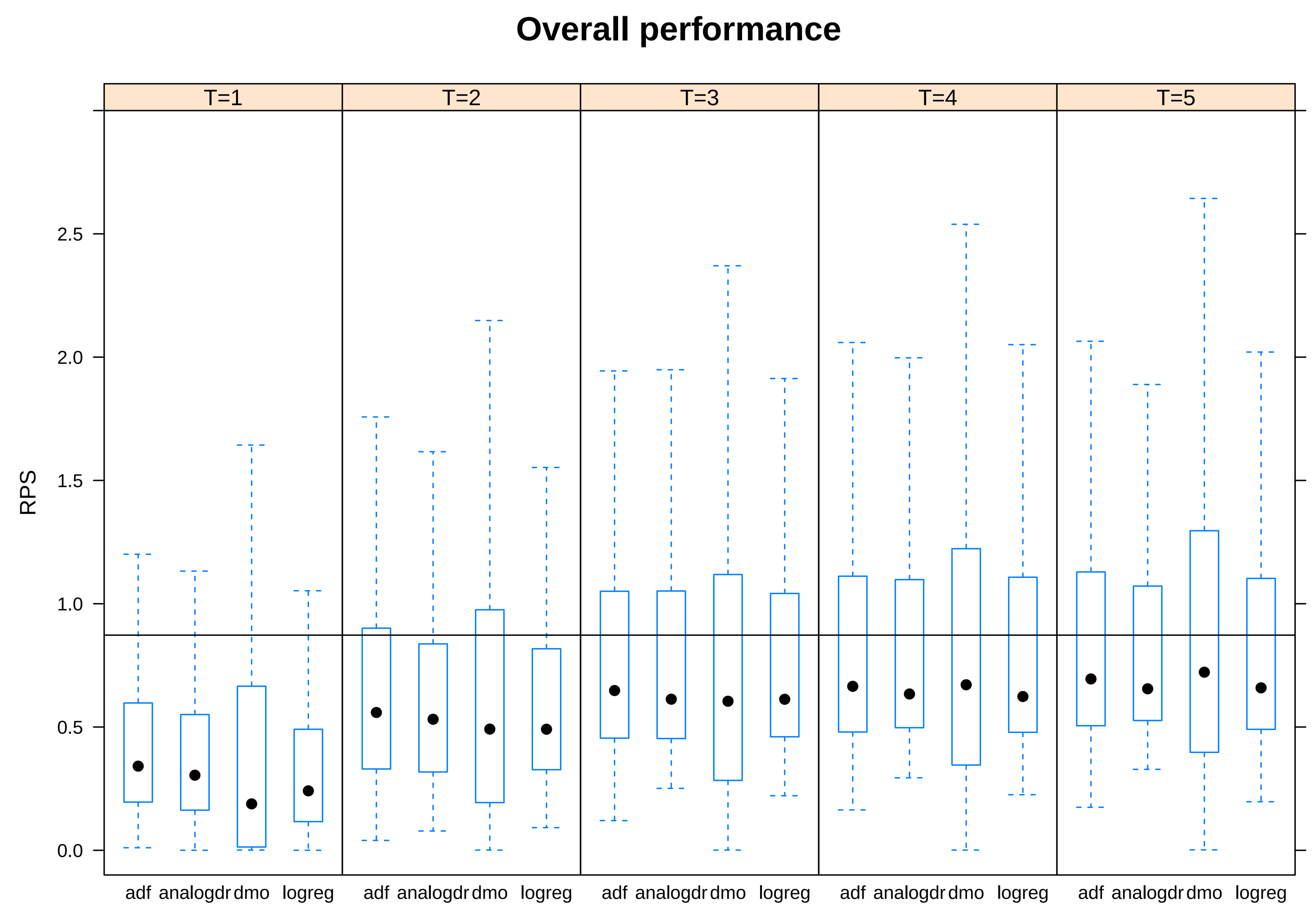


Figure 1: Ranked probability score (RPS; smaller values are better) of the two analog methods, direct model output (DMO) and logistic regression for different lead times. The RPS of the climatological relative frequencies is shown as horizontal black line.

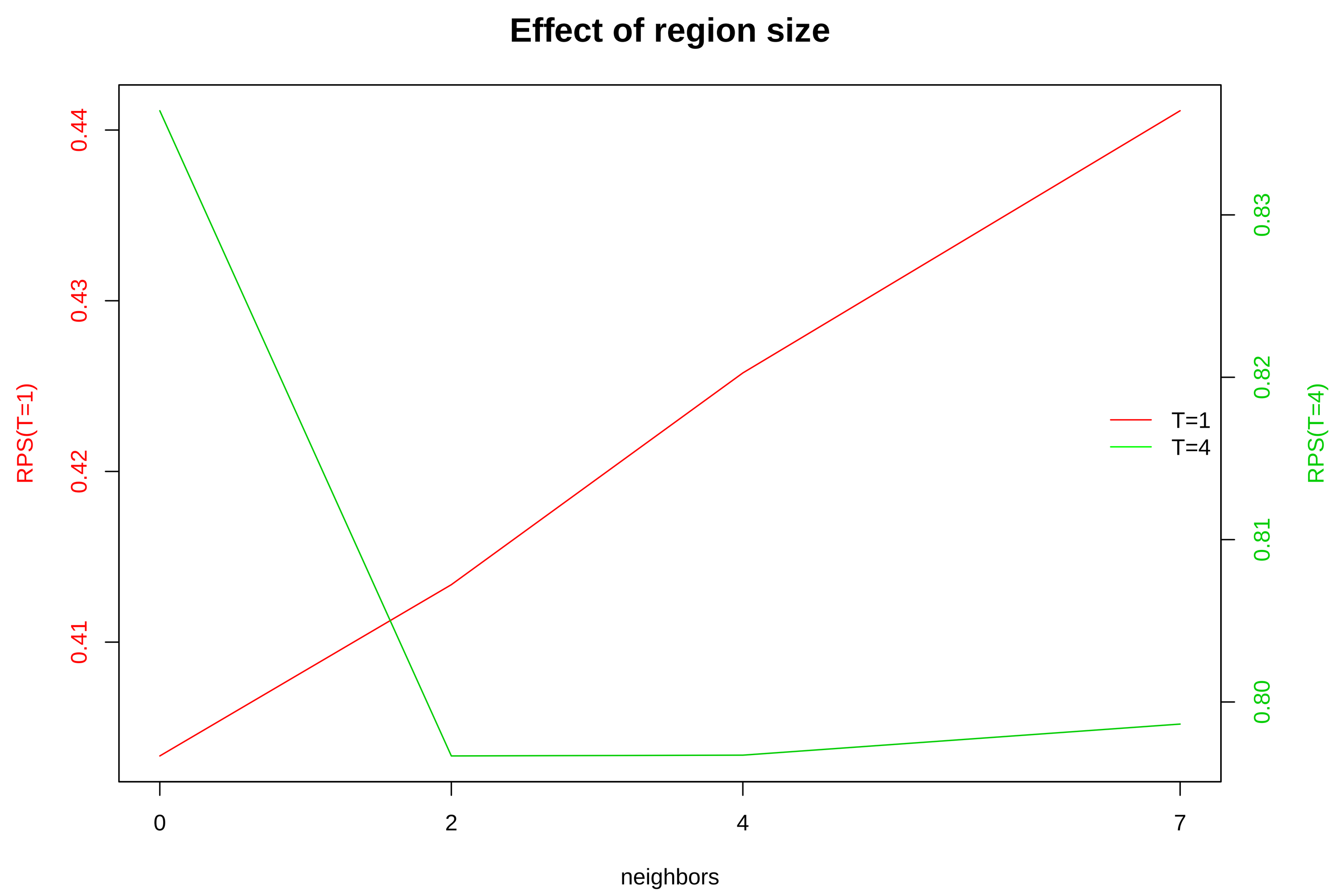


Figure 2: Effect of the region size (neighbor grid points) that is used to test similarity of two patterns on the RPS of the adf method for lead times T=1 (red) and T=4 (green).

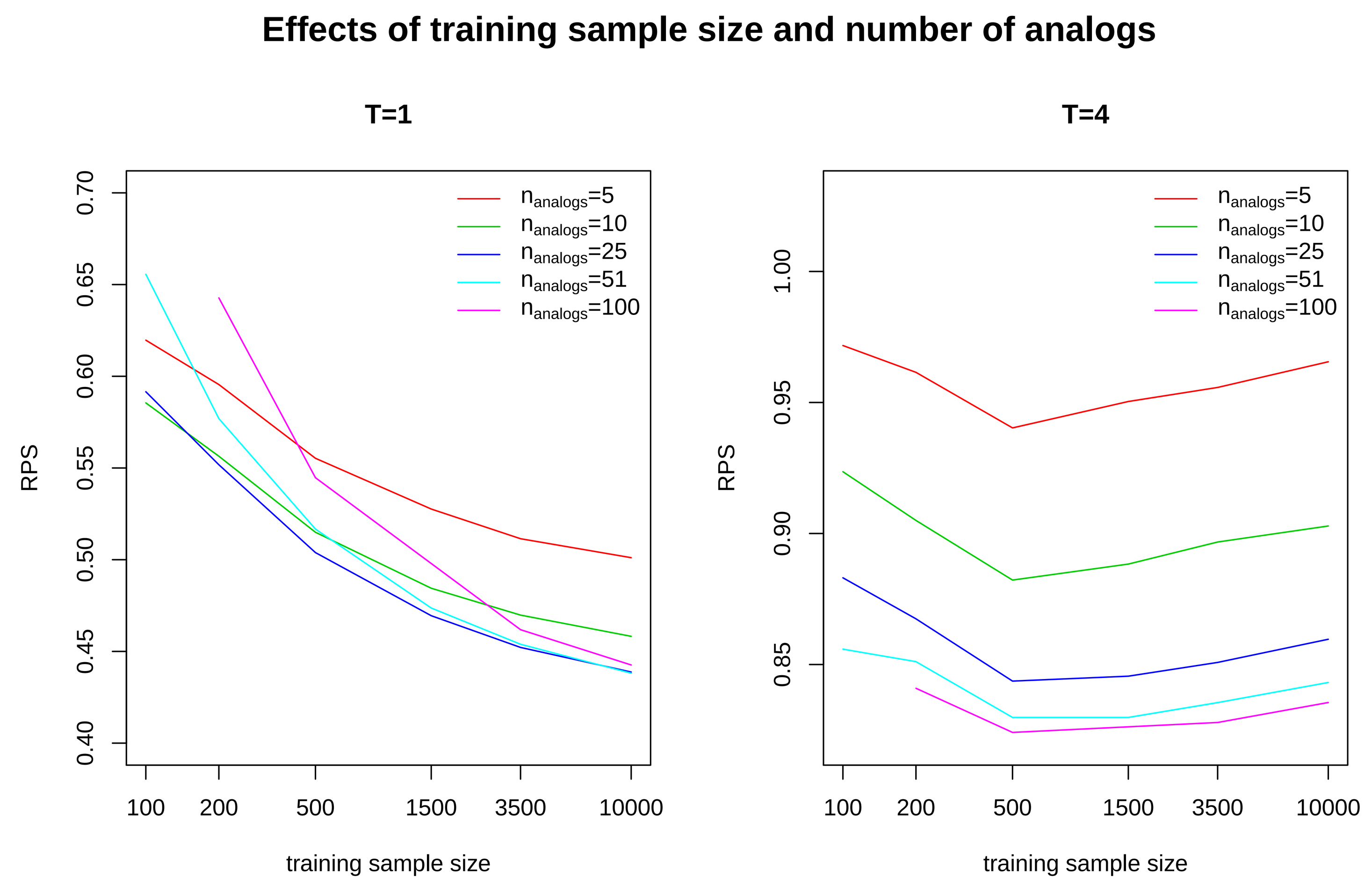


Figure 3: Effects of the training sample and the ensemble (number of analogs) size on the RPS of the adf method for lead times T=1 and T=4.

SUMMARY

Figure 1

- None of the tested methods is significantly better than the others.
- At shorter lead times the analog methods are slightly worse than the ensemble MOS methods.

Figure 2

- The optimum region size to find analog states strongly depends on the lead time.
- For longer lead times larger regions should be used.

Figure 3

- For short lead times the skill increases with increasing traning data size.
- For longer lead times there is an optimum at medium sample sizes.
- Using more analogs improves the RPS for long lead times.

Conclusion

The skill of probabilistic forecasts using analogs is similar to forecasts of other ensemble MOS methods.
The right choice of tuning parameters like region and training sample size is important to optimize the performance of analog forecasts.

Acknowledgements: This study was partly supported by the Austrian Science Fund (FWF): L615-N10

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