Is the Analog Method Able to Reconstruct Precipitation Over Europe?

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Two Main Tools in Palaeoclimatology

Climate Reconstructions

- Based on multiple proxy indicators
- Local-oriented, but also combined to create Climate Field Reconstructions (CRF)
- A number of uncertainties to be addressed

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Climate Simulations

- Many approximations in their formulation
- Forcings uncertain
- Physically consistent

Blending Both Methodologies

Exercises combining these methodologies offers a number of opportunities

- Benchmarking climate models in long-term climatic context
- Check consistence among climate reconstructions
- Testing the validity of hypothesis used in the statistical techniques employed in climate reconstructions

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The Goal

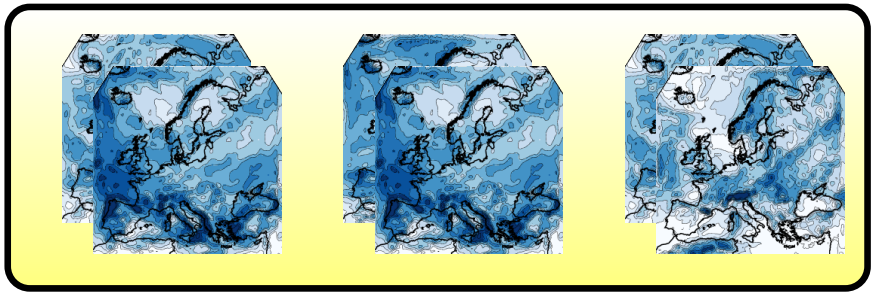
We propose a CFR technique for precipitation over Europe based in the combination of both approaches: The analog method

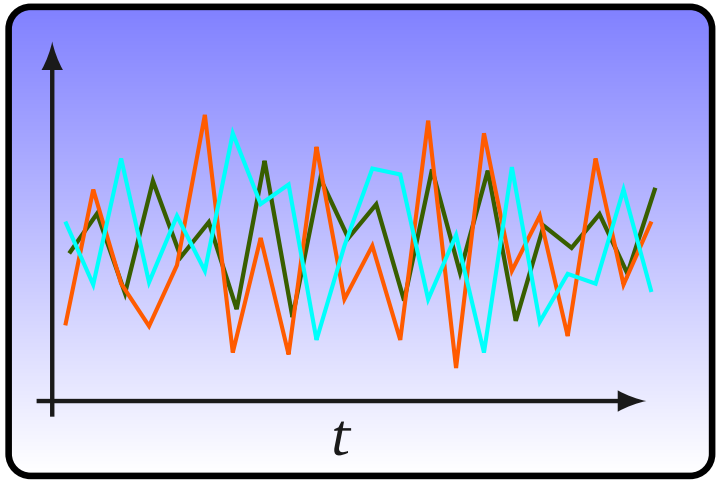
The Idea Behind the Analog Method

- Not a new idea!
- It is a method originally developed for downscaling (in weather forecast)
- The predictand is chosen from a pool of stereotypical situations based on the predictor
- Our predictor is a set of local reconstrucions of precipitation

Shuffling the Simulation

Pool of Situations





N Local Reconstructions

Shuffling the Simulation

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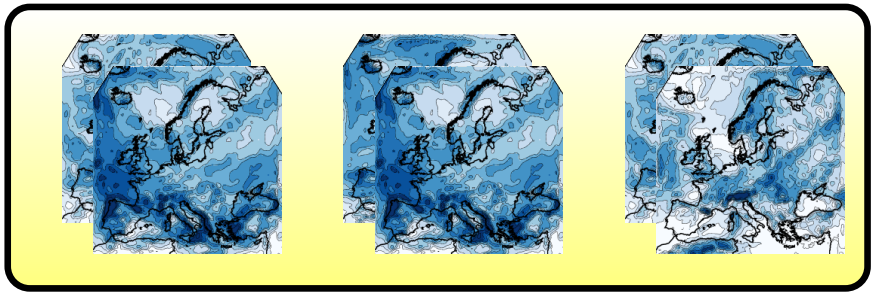
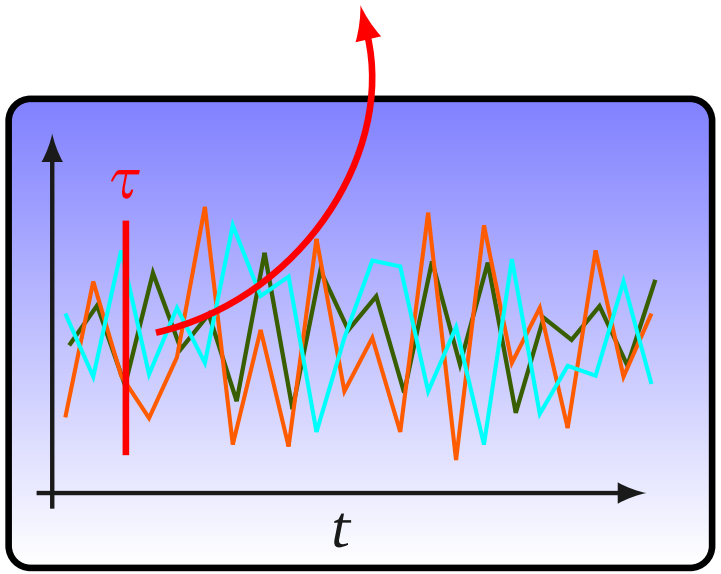


$dis(\mathbf{Pre}(u), \mathbf{P}(\tau))\ \forall u$ in pool



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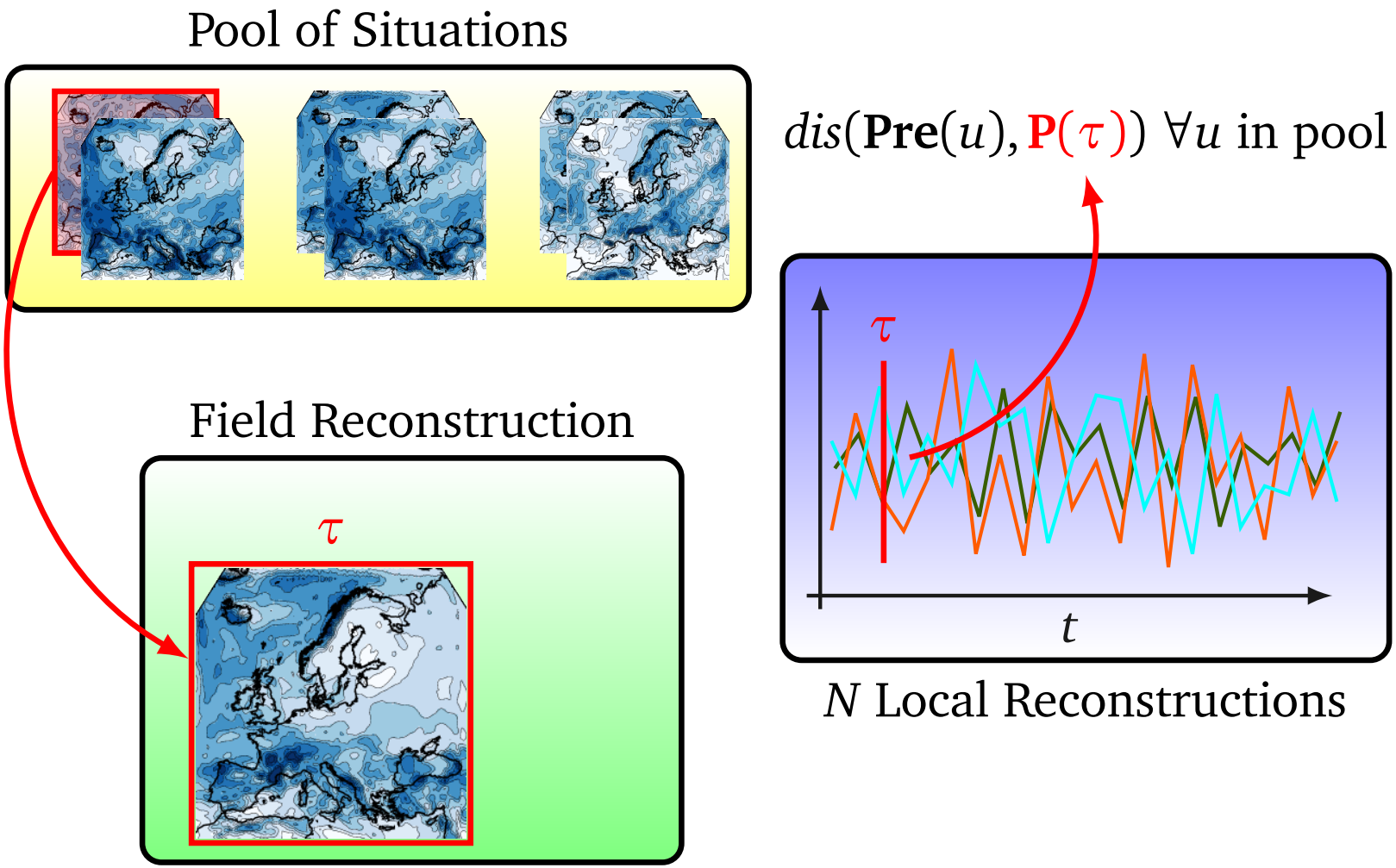

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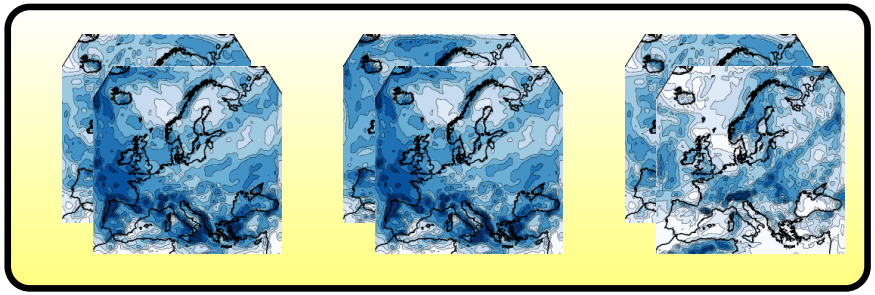
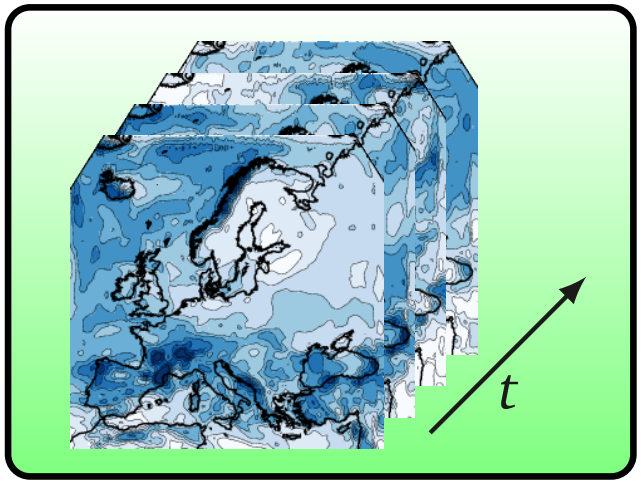
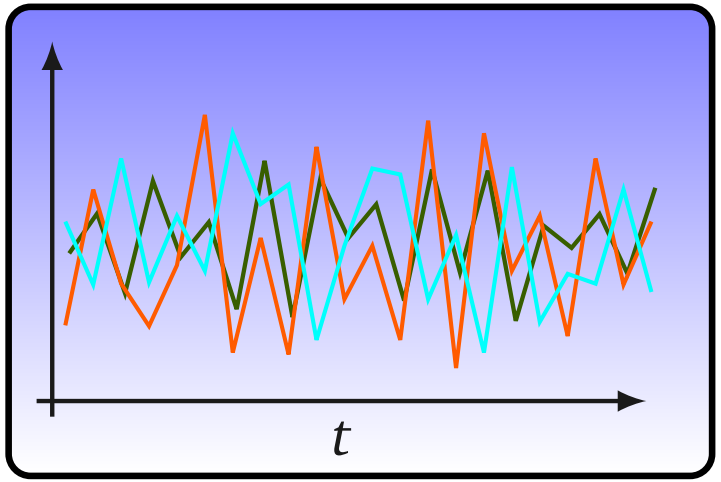


Field Reconstruction





N Local Reconstructions

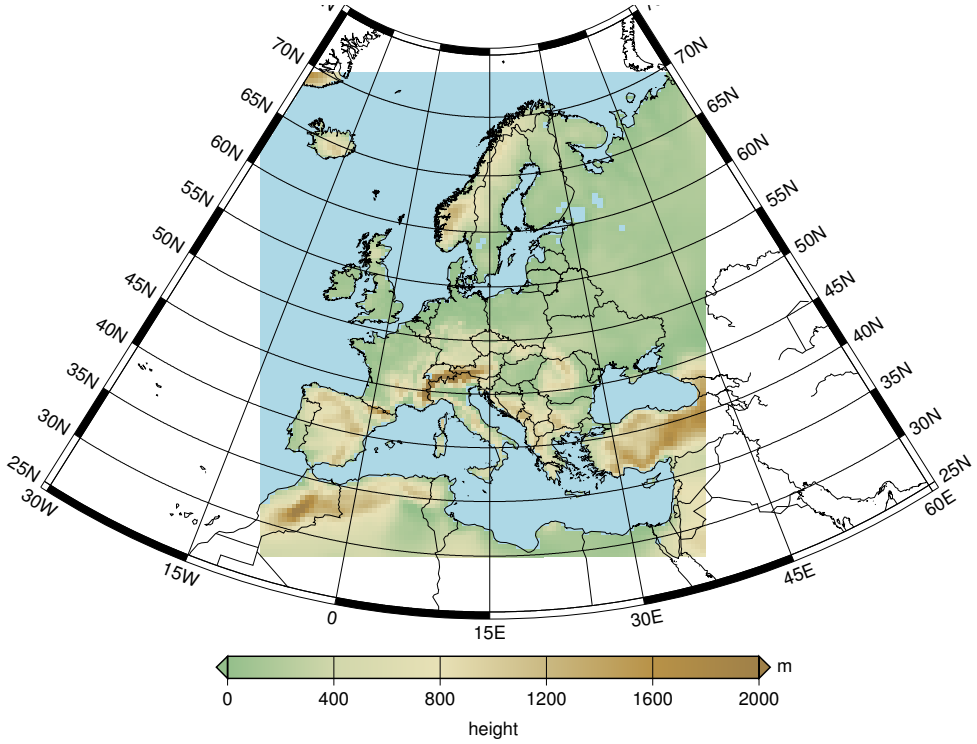
Properties of the Analog Method

This method has some advantages and caveats:

- The quality of the CFR relies on the quality of the local reconstructions used as predictors
- The size and quality of the analogs pool is critical: we need a large and reliable dataset to search for analogs
- A non-linear method (does not necessarily le variance)
- We do not need to make assumptions about the behaviour of the reconstructed field

The Pool

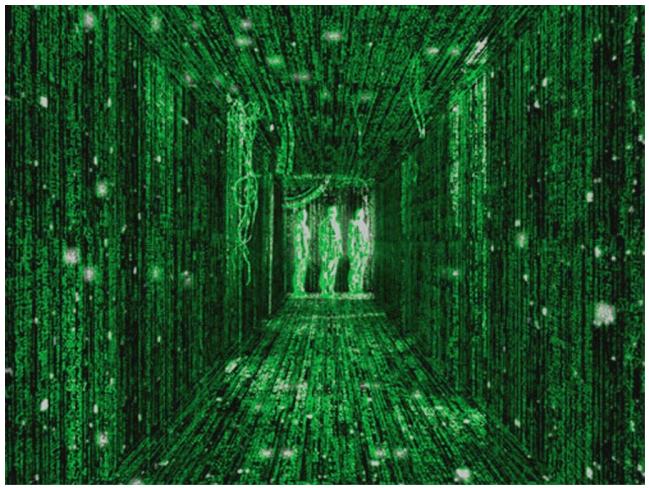
We use a 2000-year long high-resolution simulation over Europe as a pool for searching analogs



- Period 1-1998 (seasonal series)
- Driven by solar, orbital and GHG forcing
- Resolution: 45 Km
- Quality tested

Testing the Method in the Model World

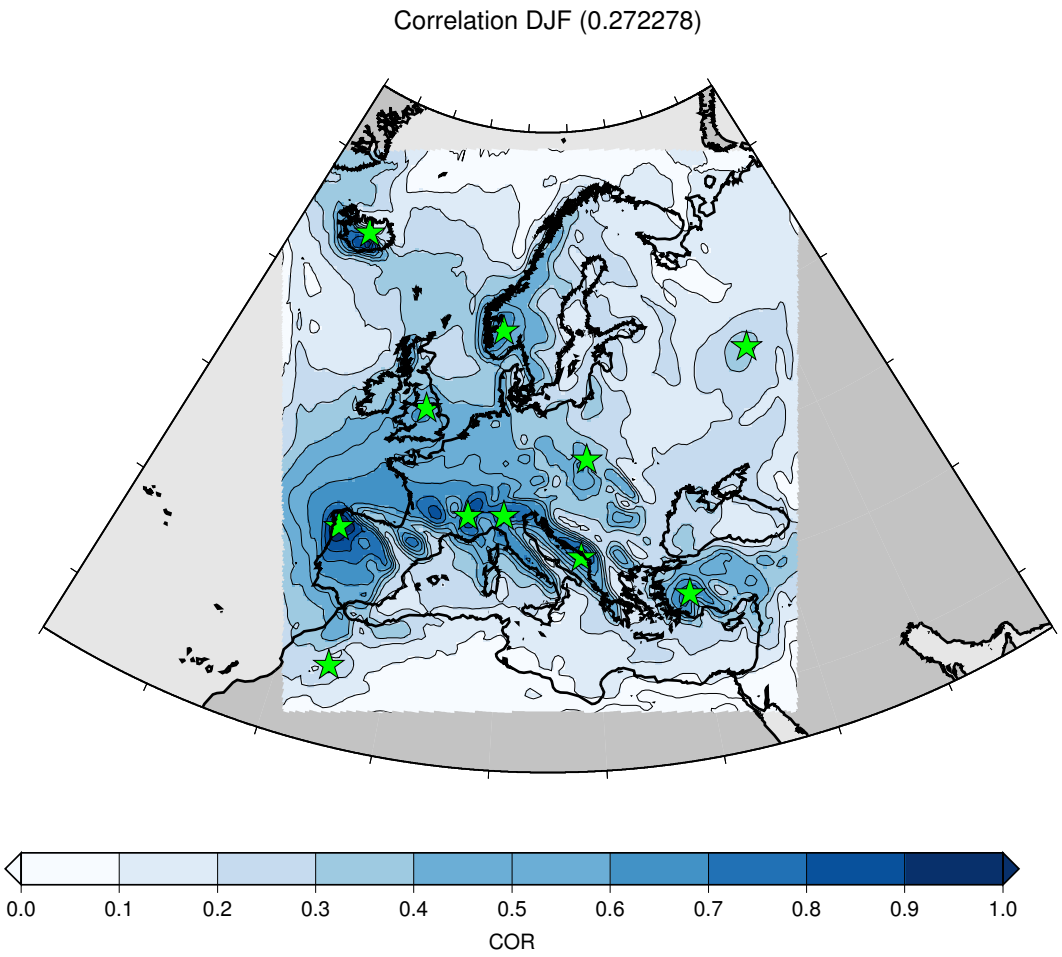
We use the model simulation as a *pseudo-reality* where pseudo-proxy experiments (PPE) can be performed:



1: Simulated series in 11 locations are extracted and contaminated with noise
2: The CFR methodology is applied to these pseudo-proxies
3: The "reconstruction" is compared with the "reality" to asses the skill of the reconstruction methodology

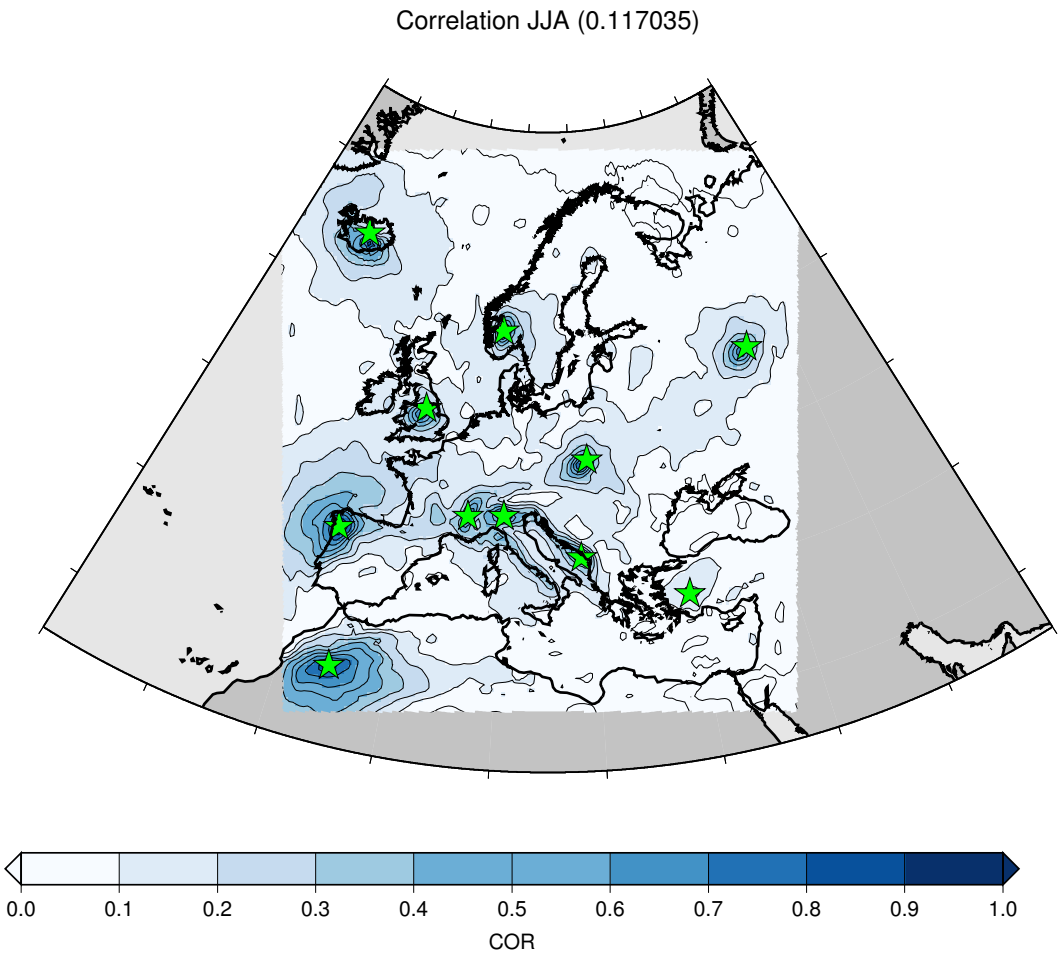
Correlation in the Noise-free PPE (Winter)

We first have tried a noise-free (ideal case) PPE



Correlation in the Noise-free PPE (Summer)

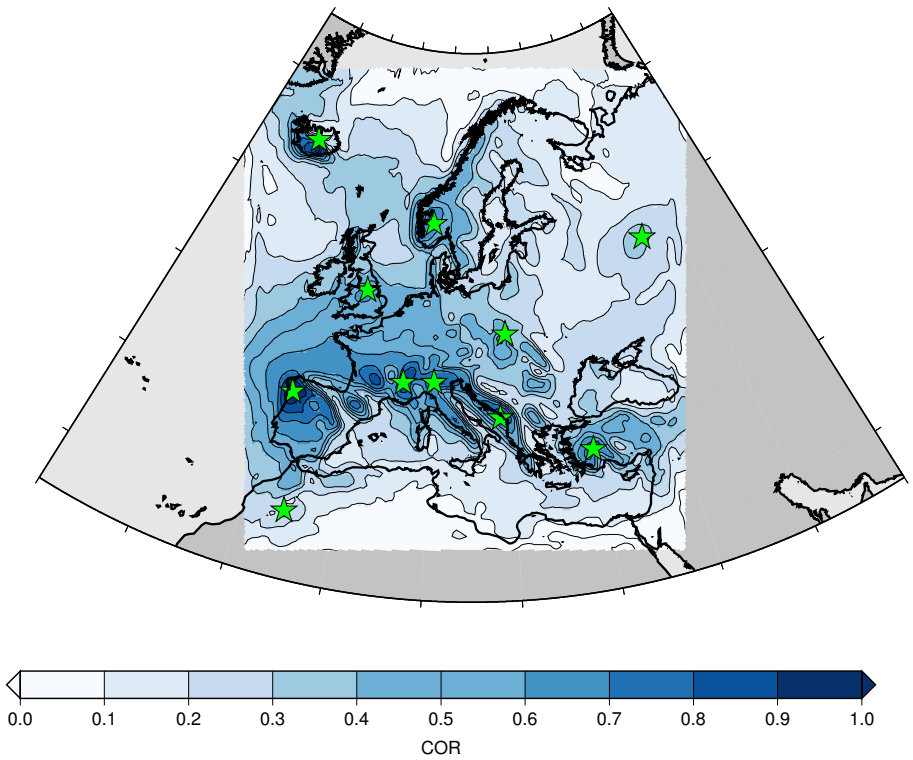
But in summer the large-scale influence on precipitation is lower, which reduces the skill



Correlation and Number of Analogs (Winter)

When several analogs are averaged, correlation increases...

1 Analog



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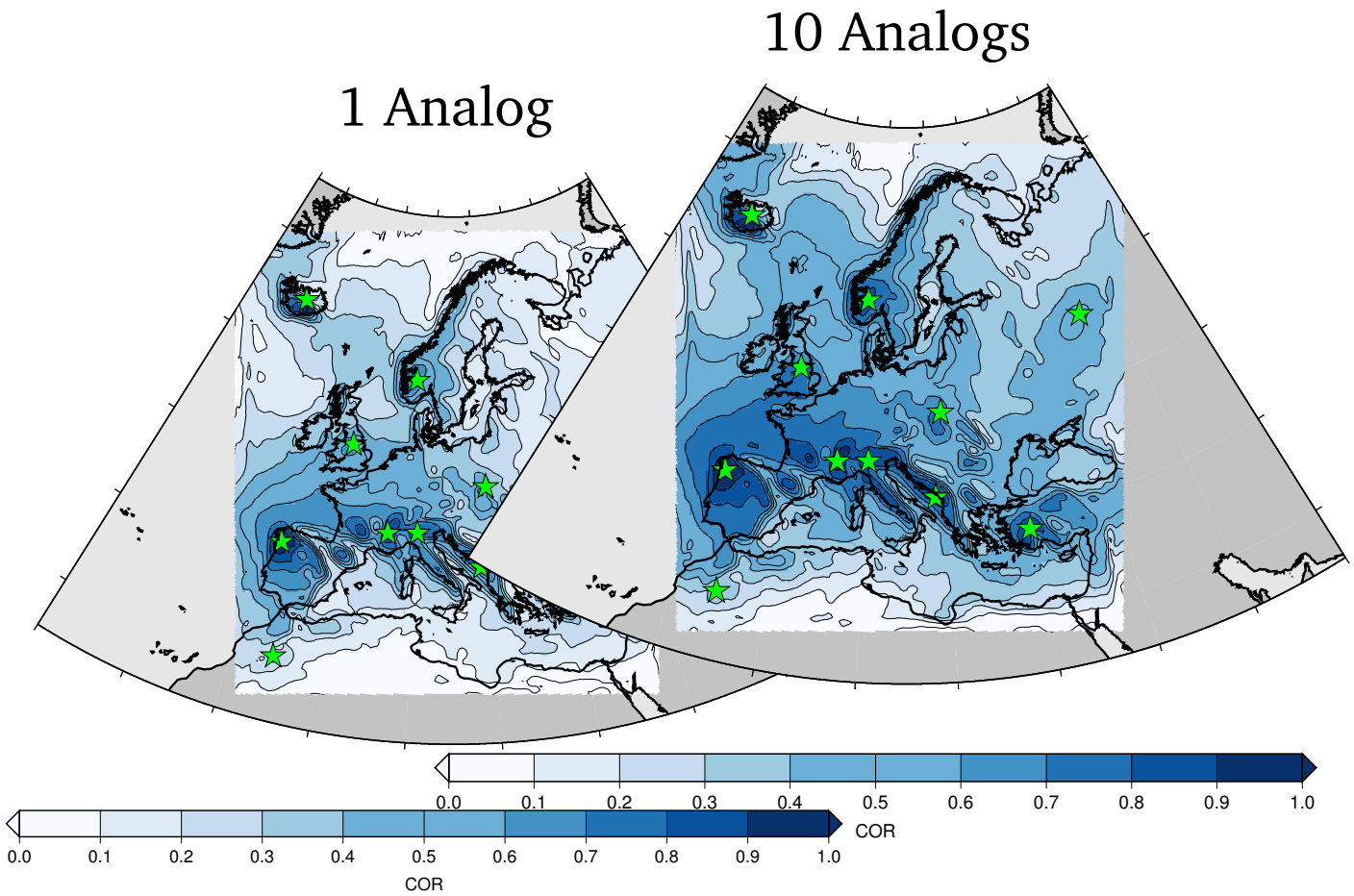
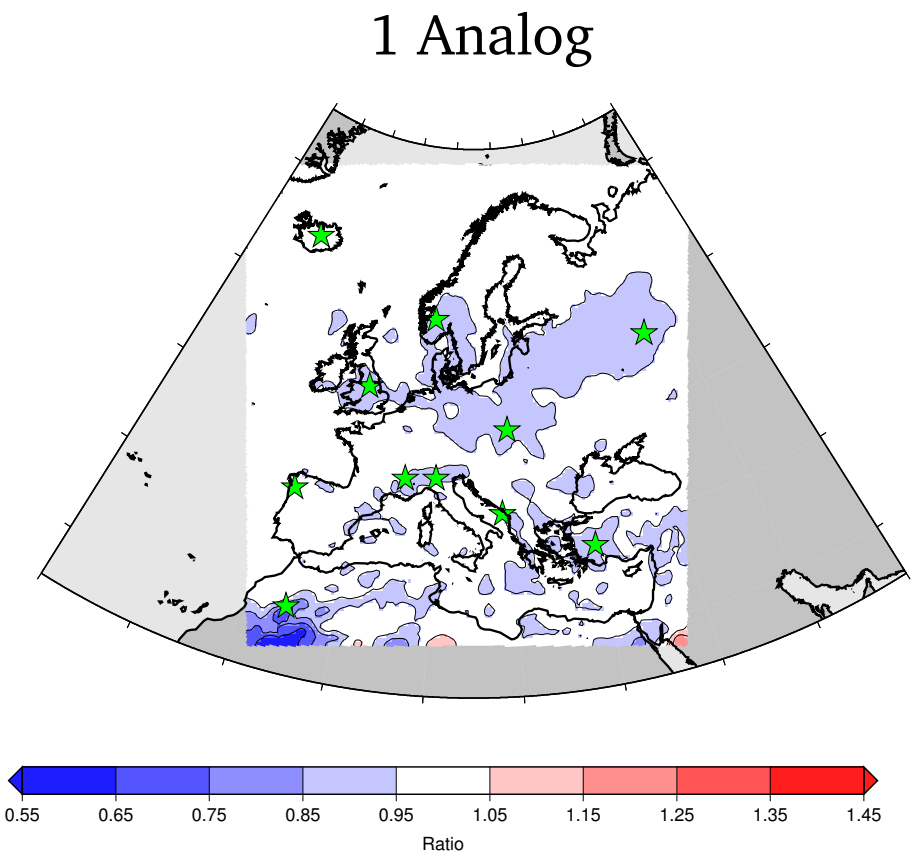


Variance and Number of Analogs (Winter)

... but variance decreases



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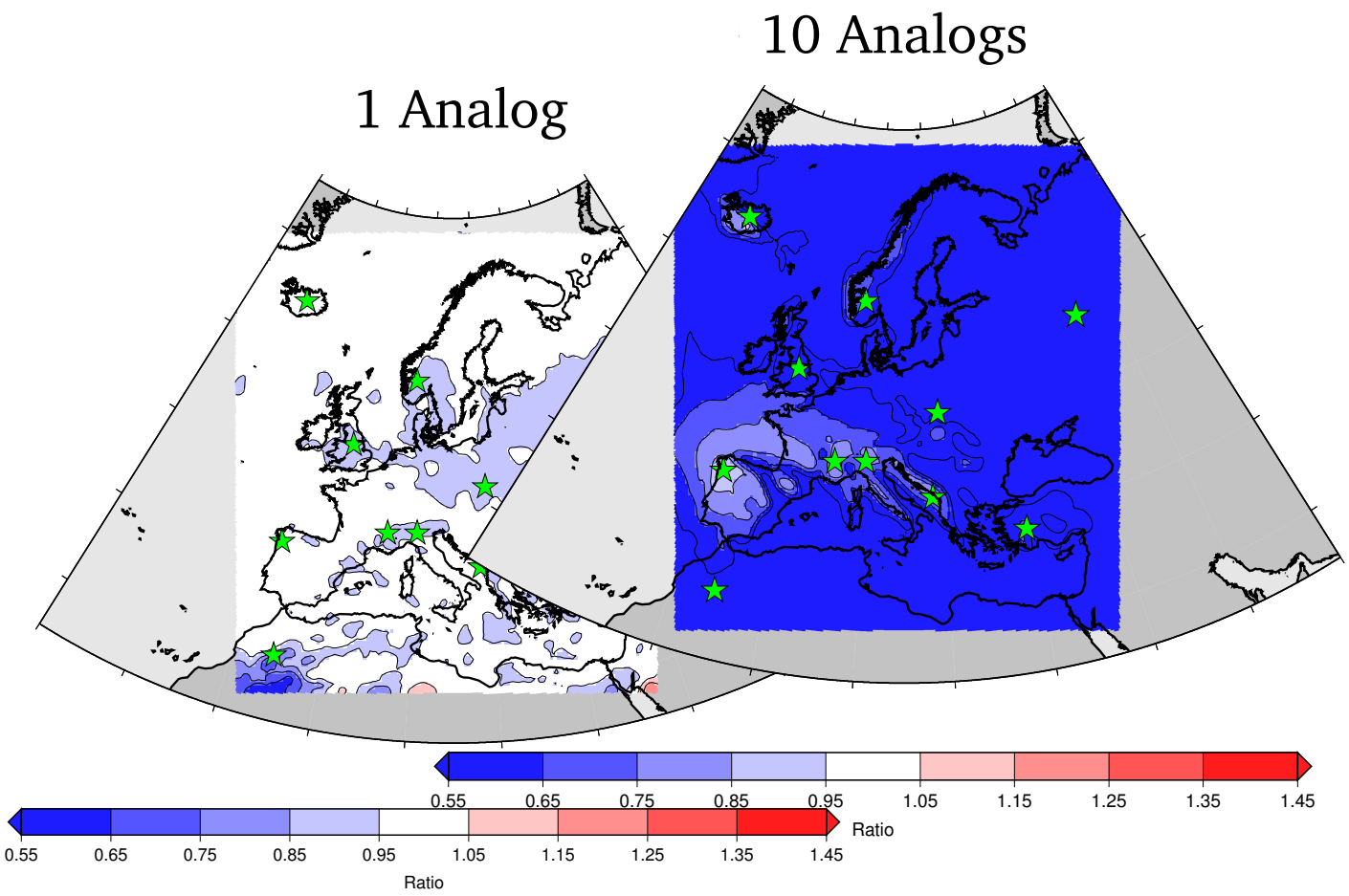


Including Noise to Simulate realistic Pseudo-Proxies

- The results shown so far are the baseline to illustrate a perfect scenario
- But real proxies contain uncertainty
- We add white noise with the simple formula:

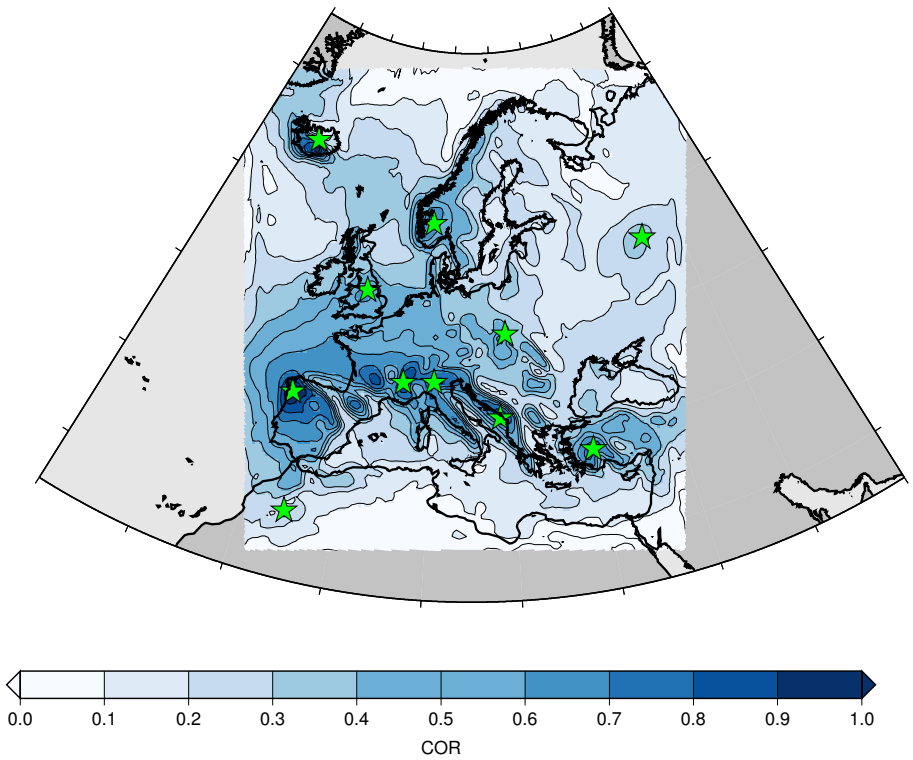
$$\hat{P}_i(t) = P_i(t) + \alpha_i W(t)$$

where $W \sim N(0,1)$ and α_i is scaled so that $\mathrm{Cor}(\hat{P}, P) = 0.5$

Correlation When Noise Is Included (Winter)

The noise decreases the skill of the pseudo-reconstruction

Noise Free



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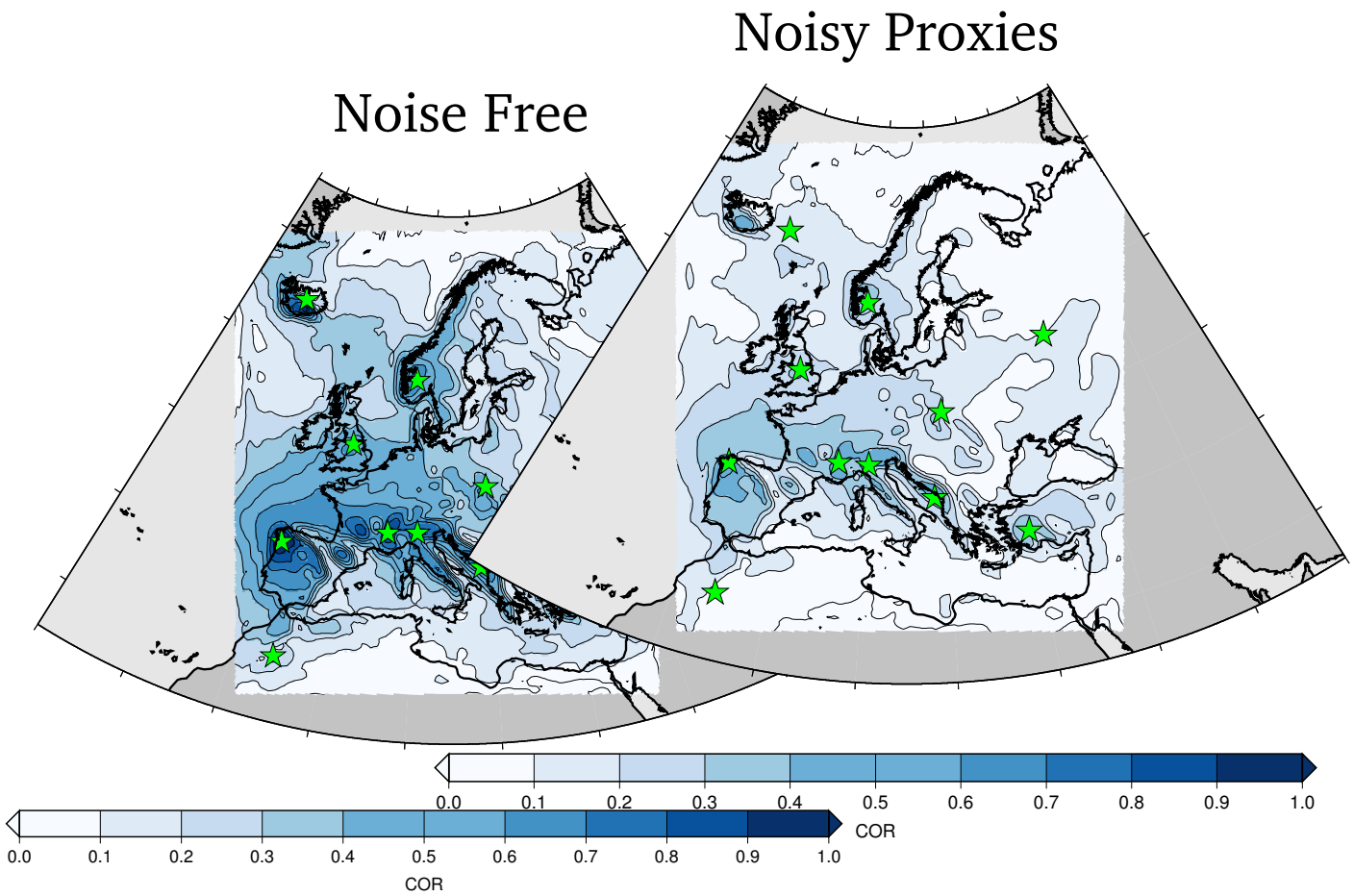

Conclusions

- The analog method can be combined with long, high-resolution simulations to perform seasonal CFR of precipitation
- The noise-free experiment represents the theoretical limit for the skill of the method
- Skillful reconstruction close to the PPE locations
- Not so skillful in areas where few input information is available, especially in summer
- There is trade off between correlation and variability
- Create several reconstructions at different temporal scales?

Conclusions

Thank you!