Verification and application of the Analogue-Method to project local scale precipitation from different GCM scenarios: a case study within the Sierra Nevada and the European Alps.

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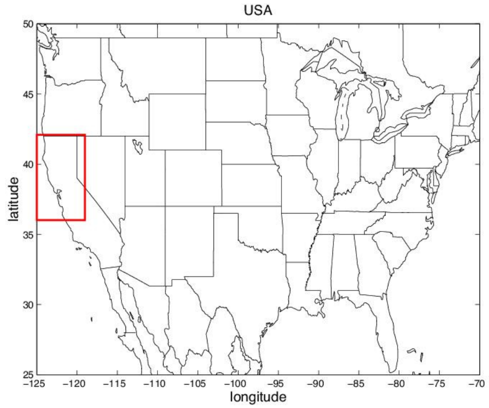
Motivation

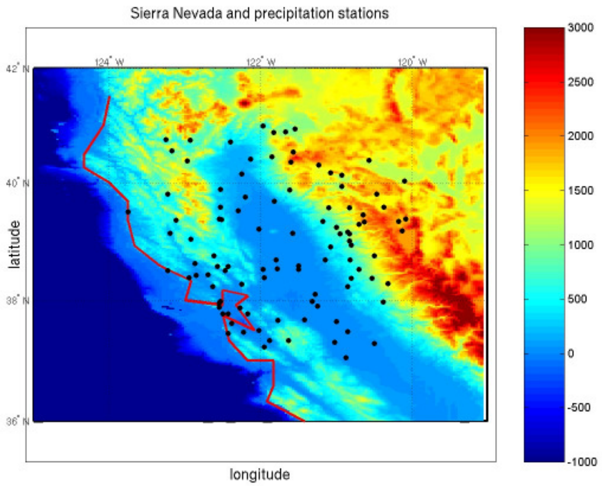
- we are investigating the variability of daily precipitation and its possible future behaviour;
- we derive regional scale changes that are in accordance with IPCC emission scenarios (realized by the use of GCMs);
- To be useful for subsequent hydrological studies these regional scale scenarios should be spatially reasonable;
- The Analogue-Method is a good candidate to fulfill these needs.

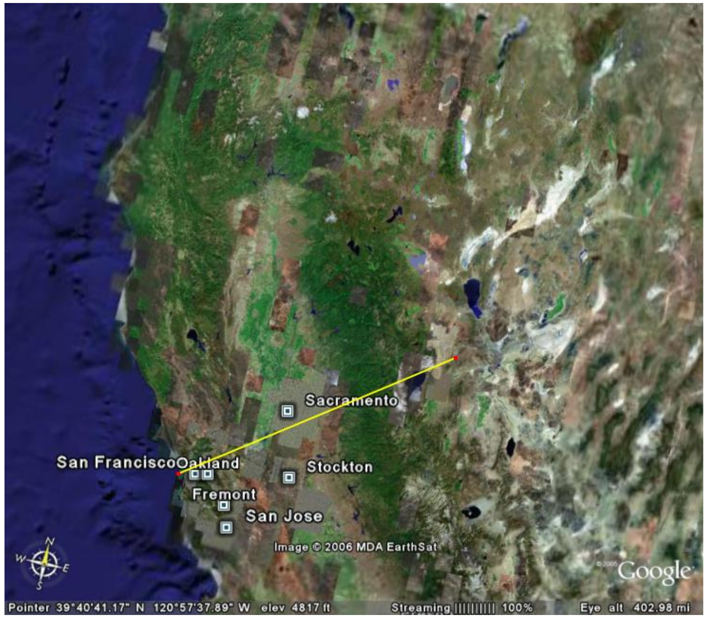
Analogue-Method (AM)

- Every time we use acquired knowledge to estimate the future the AM is applied. AM is a process that uses historical information to predict future evolutions;
- Applications within Meteorology range from weather forecasting to climatologic aspects and the AM has been widely used: Lorenz 1969, …, Zorita and von Storch 1999, …
- AM allows for a consistent transfer of changes in large scale climate (‘scenarios’ as simulated by GCMs) into changes of the local scale climate (i.e. Downscaling see e.g. von Storch et al. 1993);

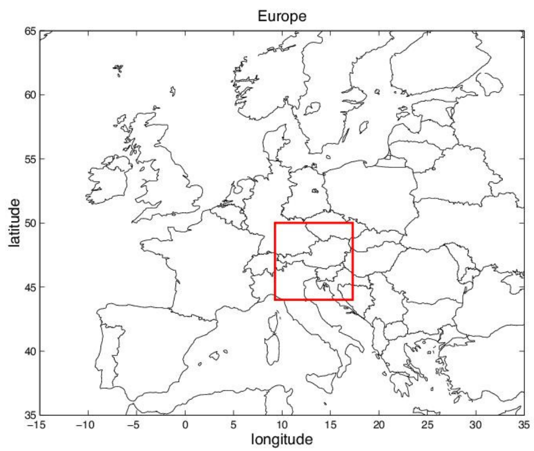
- **Here we’ll present the dependence of AM’s performance to simulate daily precipitation on different measures of similarity. This will be investigated within the US Sierra Nevada (SN), California’s Central Valley (CCV) and the European Alps (EA). Thereby we concentrate on January.**

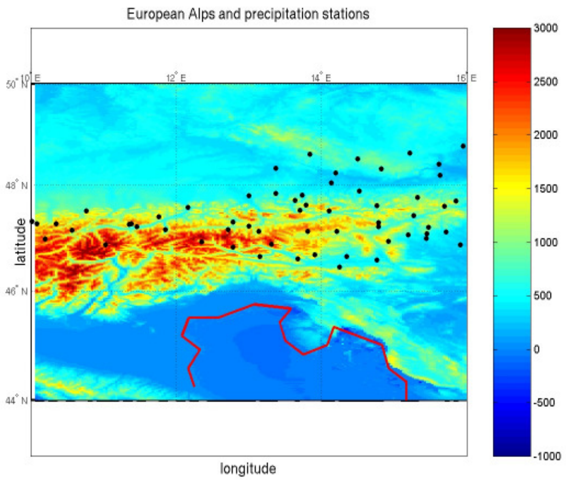


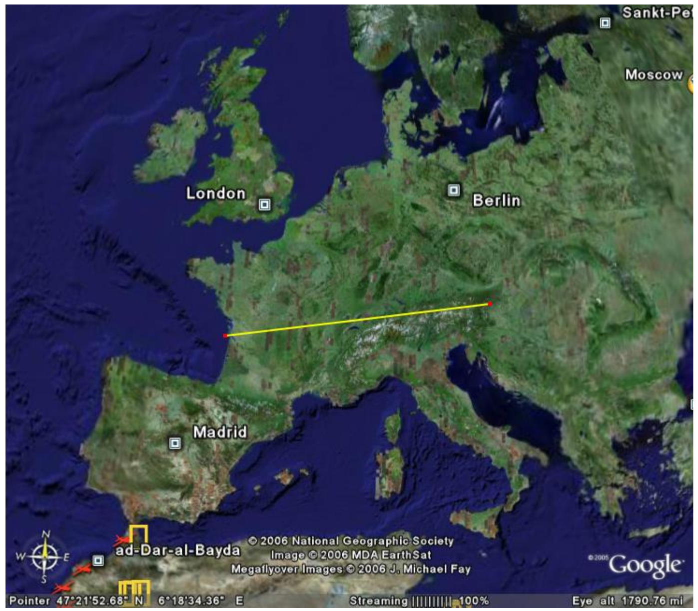




Mountain range: normal/parallel to the main air flow; distance from the ocean: 300/1200km; max precipitation sums during: winter/summer







NCEP/NCAR or ERA40 reanalysis-data (SLP, spec hum 700hPa see e.g. Pandey et al. 1999)

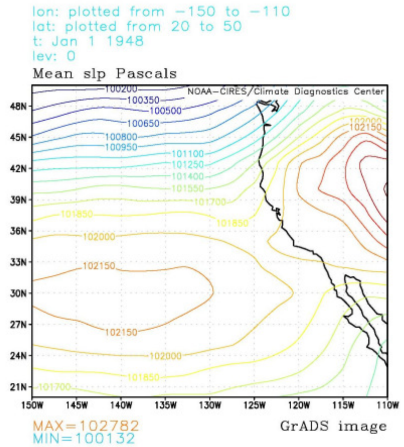
Daily obs. precipitation sums

What information do we have?

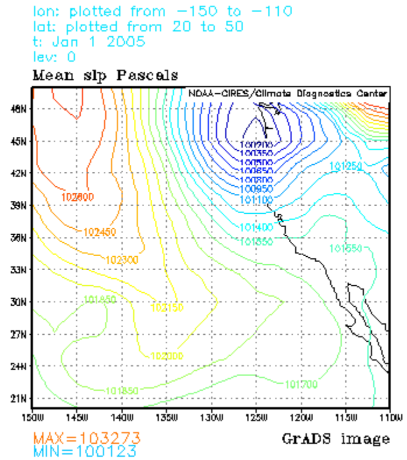
Historical information ***H***

Scenario information ***S*** for the future

large scale

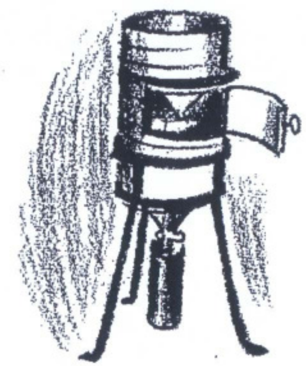


Reanalysis products (NCEP/NCAR or ERA40)



GCM realizations according to different emission scenarios

local scale



Observational records

$$H = \{h_1, \ldots, h_k\}$$

$\forall h_i\ \exists$ large and local scale information

$$S = \{s_1, \ldots, s_n\}$$

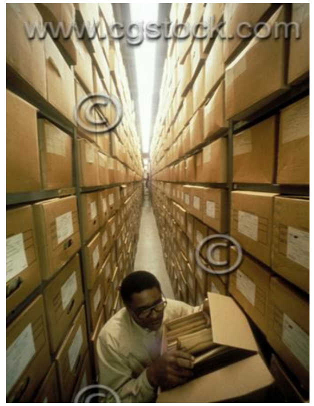
$\forall s_j\ \exists$ large scale information

What is AM actually doing here?

for every date s_j in S AM takes the large scale atmospheric pattern and compares it to the observed large scale patterns of all the dates h_n in H

AM chooses the most similar historical circulation pattern and thereby address to every s_j a specific h_k

AM assigns the local scale pattern of date h_k to date s_j. This generates local scale information for all s_j in S.



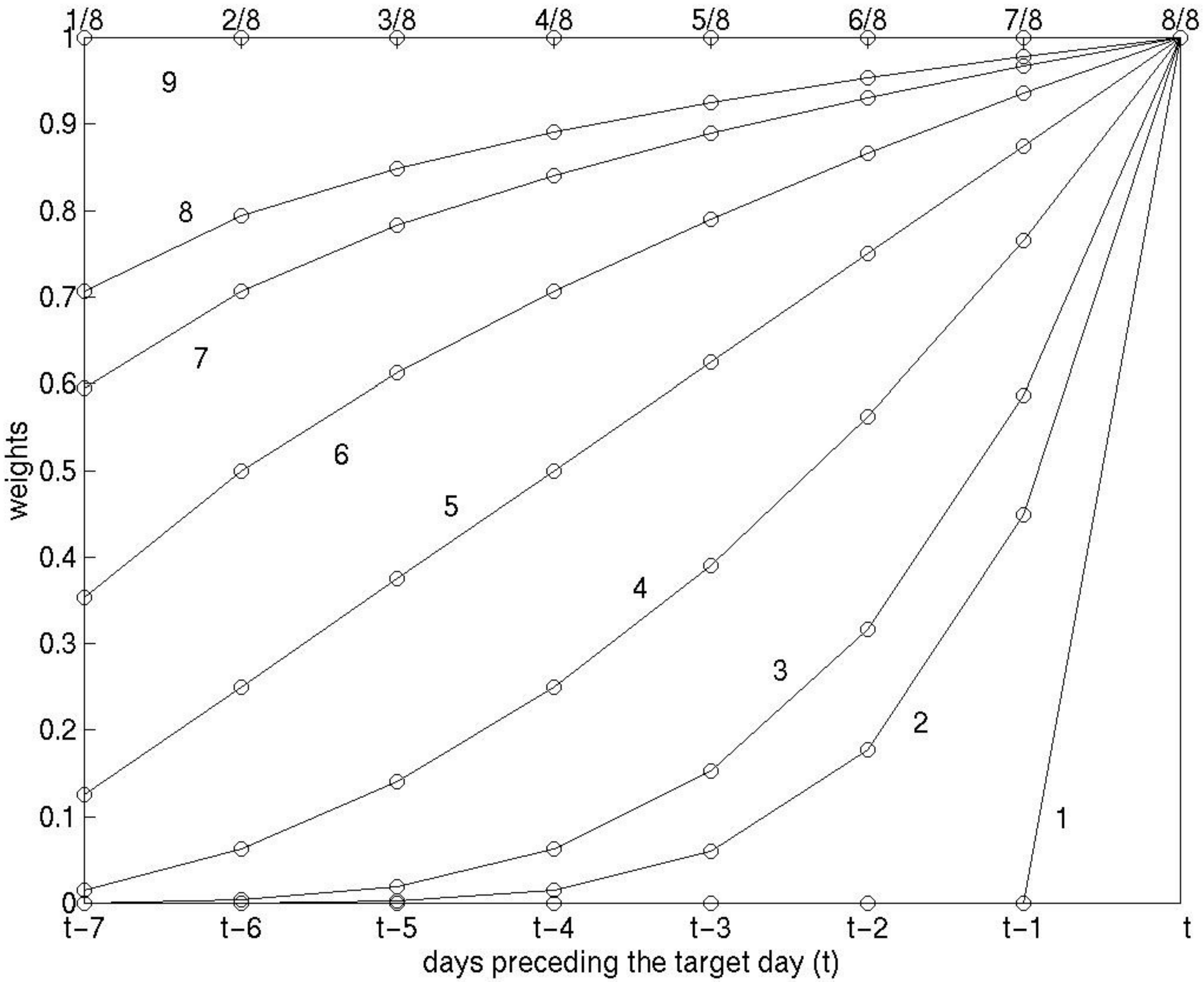
That’s trivial, but what’s ‘most similar’?

- That deals with the similarity of patterns or in other words with some kind of distance between atmospheric state-vectors (n*10^2 dim);
- To reduce the degrees of freedom we enter the atmospheric patterns into an EOF analysis. To study the dependence on the truncation → 6 different dimensions of the vector-space (5,8,...,20);
- And we apply different ways of quantifying similarity → 5 ways to quantify similarity;
- In order to include knowledge about the atmospheric evolution we investigate daily sequences of large scale patterns → 9 weighting sequences.

How do we quantify similarity?

- Euclidean Norm (L_2)
- ‘xplvrz’ -- as Euclidean but with weights attached to the single components (weights correspond to the explained variances; see e.g. Zorita and von Storch 1999)
- L_1
- Cosine of the angle between state-vectors
- Mahalobis (Yambor et al. 2002; weights correspond to the negative inverse square-root of the eigenvalues)

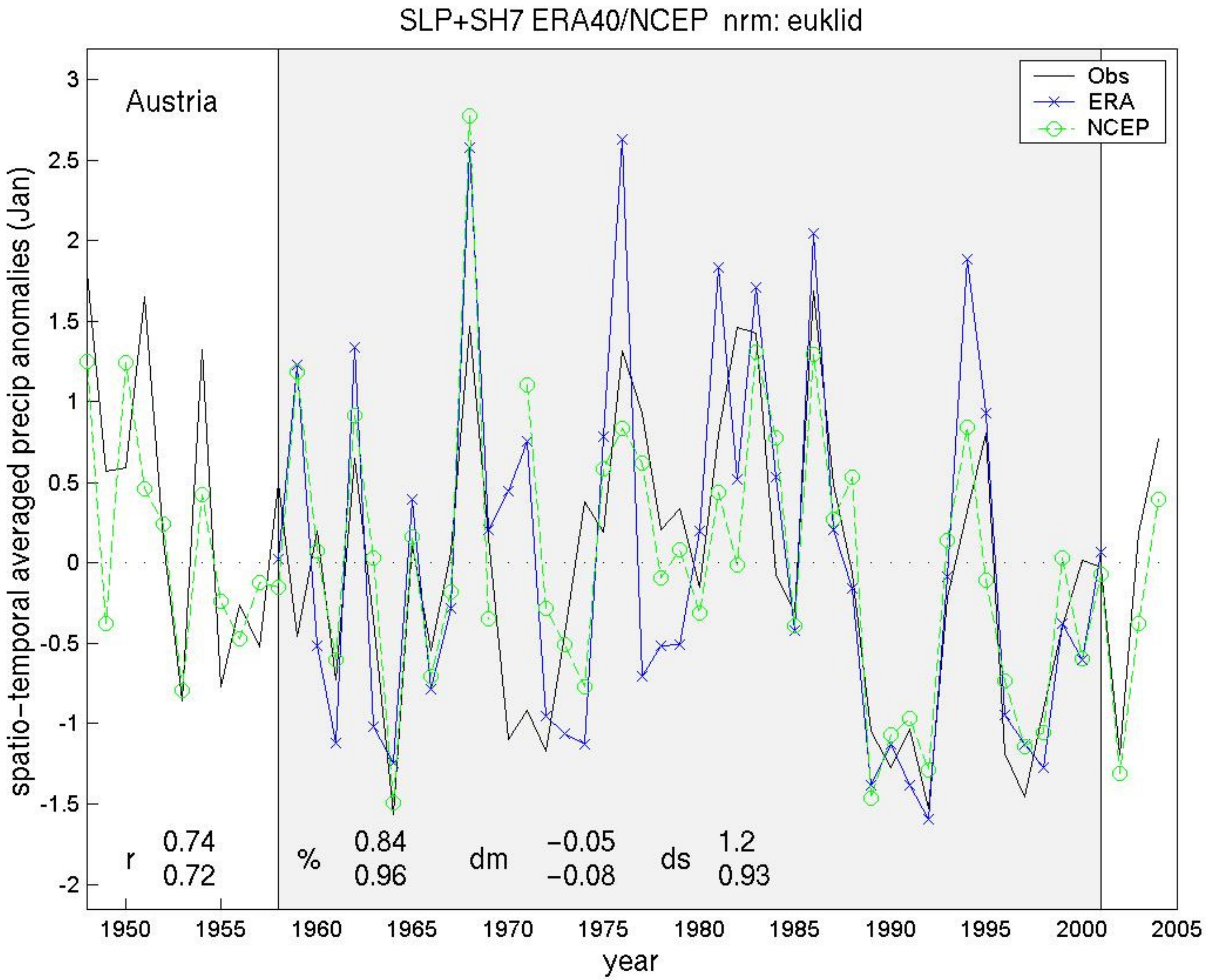
Weighting sequences



Validation experiment

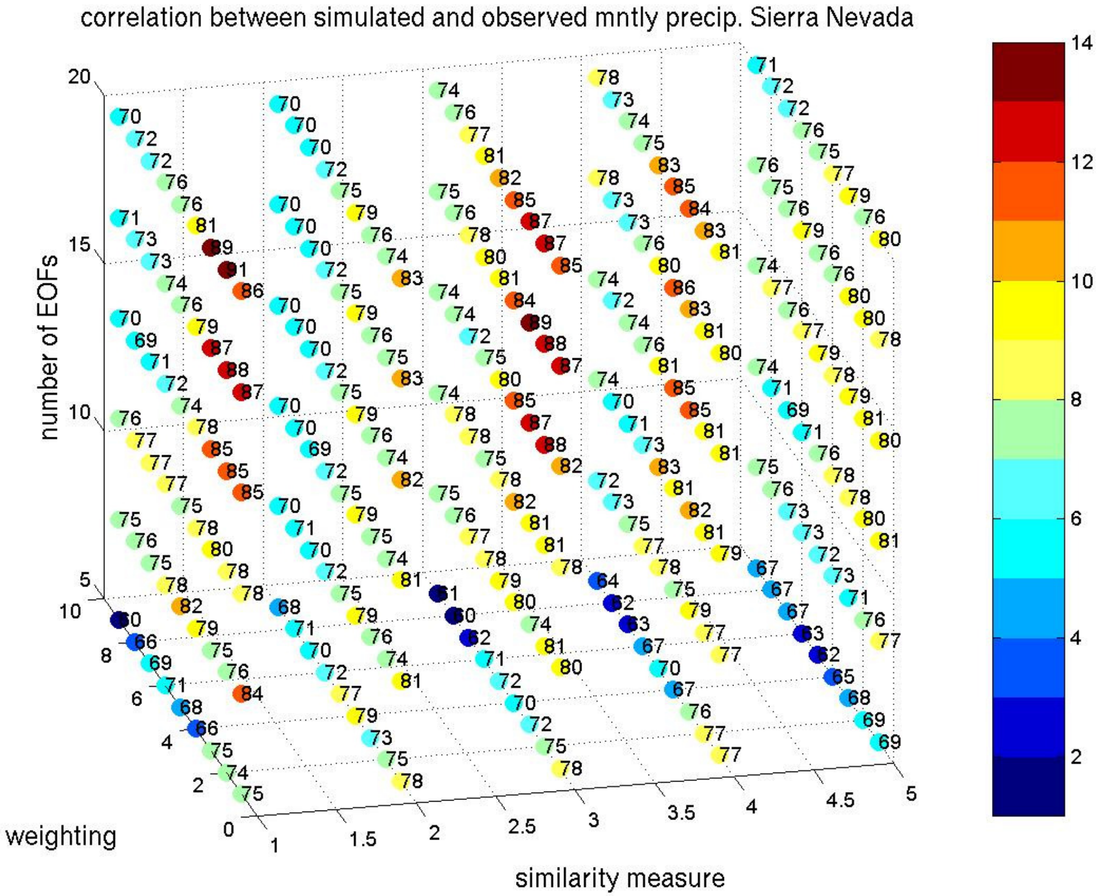
- Temporal cross validation (i.e. ***H***= the total observation period except from the year which is actually simulated= ***S***).
- We concentrate on January as January's weather patterns show a spatial coherency on scales up to and beyond 100 km (Osborn and Hulme 1997)
- Results shown here refer to a daily and monthly time scales.

Reproduction of monthly precipitation sums

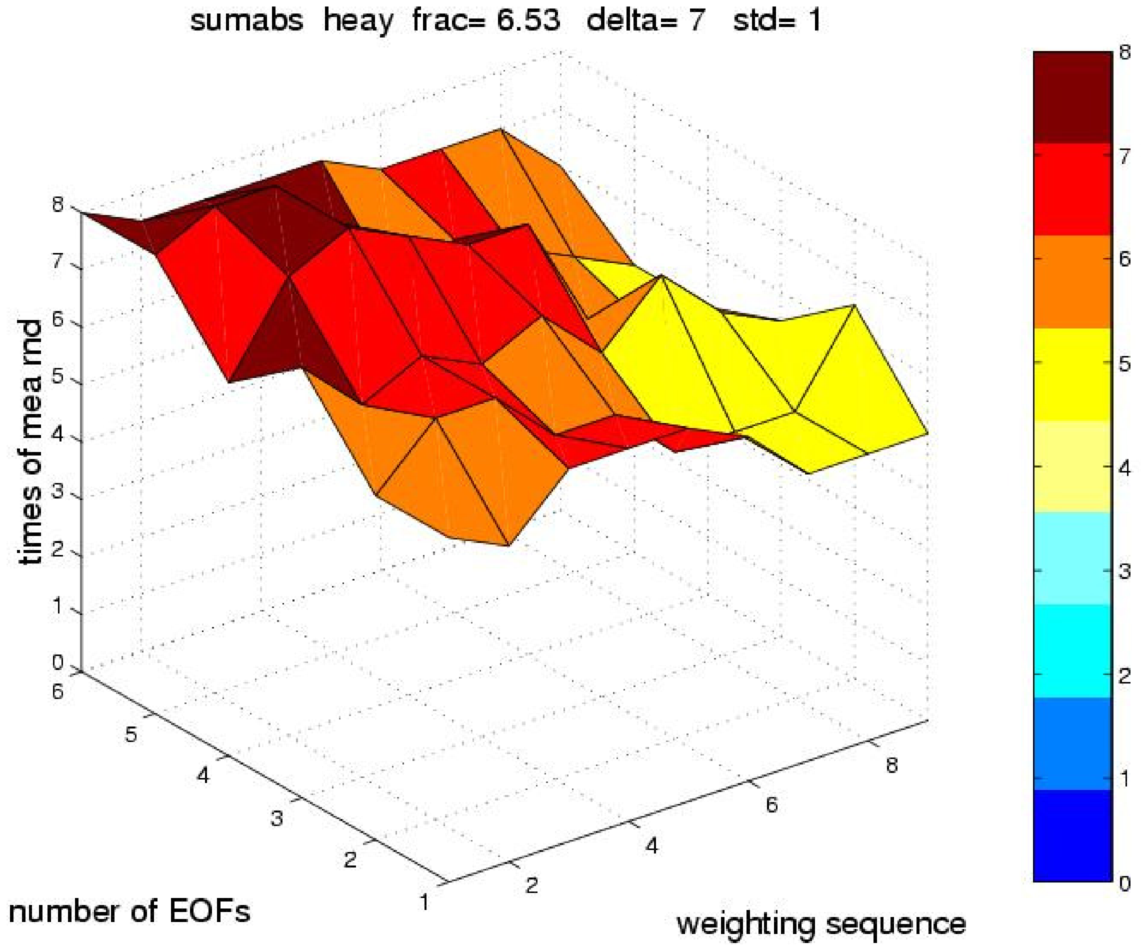


European Alps (AM plus NCEP/NCAR and AM plus ERA40)

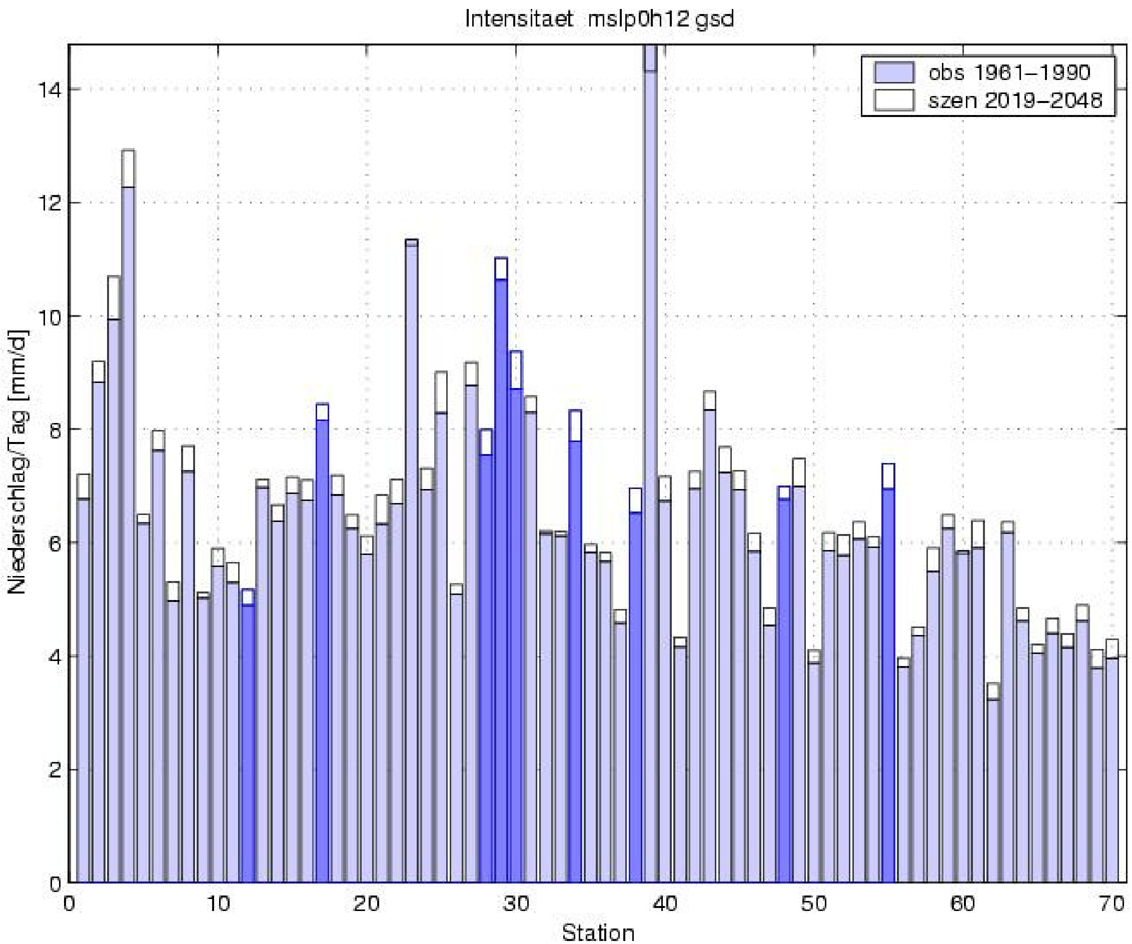
5 ‘norms’ * 9 weighting sequences * 6 EOF spaces * 2 locations = 540 experiments ~30,000 simulated months



Probability of a correct heavy prec. (>P_{95}) estimate using AM compared/relative to random draw



Possible changes in the intensity of precipitation events



Matulla et al. 2004

Preliminary result for the European Alps using IPCC IS92a GSD scenario as realized by the ECHAM4 GCM at DKRZ, Hamburg, Germany

Conclusions and Outlook

- AM's performance is sensitive to different similarity measures, weighting sequences and to the number of retained EOFs. Results are in general better for low indexed weighting systems and EOF spaces that include aspects of regional structures;
- AM's performance is generally higher in the Sierra Nevada and California's Central Valley than in the European Alps; This may be caused by the larger distance of EA and their orientation to the ocean and thus by a weaker dependence of precipitation events on SLP patterns;
- AM shows some skill in forecasting daily precipitation events that increases (relative to random draw) for stronger events;
- On a monthly time-scale AM shows a good performance in estimating wet and dry local scale conditions from large scale circulation;
- Euclid, L1 and cosine are performing better than xplvrz and Mahalobis. This may be related to the deforming of the phase space caused by the latter two;
- This result suggests a clustering of weather patterns within cones of the phase space, which may be related to different weather types.

Literature

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- Thank you very much and enjoy your evening!