Introducing a moving time window in the analogue method for precipitation prediction to find better analogue situations at a sub-daily time step

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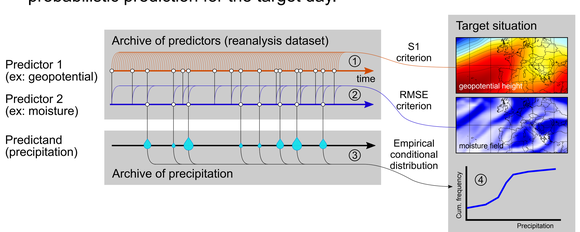
Introduction

Analogue methods (AMs) predict local weather variables (predictands) such as precipitation by means of a statistical relationship with predictors at a synoptic scale. The search for candidate situations similar to a given target day is **usually** undertaken by comparing the state of the atmosphere at **fixed hours** of the day for both the target day and the candidate analogues. This is a consequence of using daily precipitation time series, which are available over longer periods than sub-daily data. However, it is unlikely for the best analogy to occur at the exact same hour for the target and candidate situations. A **better analogue situation** may be found with a **time shift** of several hours since a better fit can occur at different times of the day. In order to assess the potential for finding better analogues at a different hour, a **moving time window (MTW)** has been introduced.

The analogue method

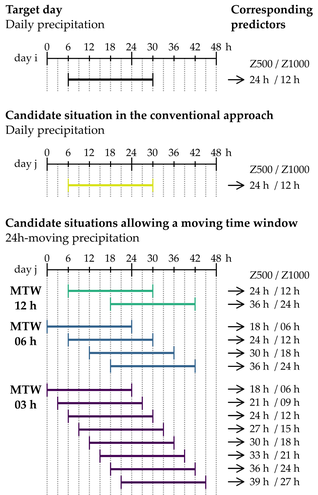
Preselection — to cope with seasonal effects, N0 candidate dates are extracted from the archive within a period of four months centered around the target date, for every year of the archive.

(1) **First level of analogy** — N1 dates are selected, by means of an analogy ranking on geopotential heights (Z) with the S1 criterion (Teweles and Wobus, 1954): Z500 @ 12h & Z1000 @ 24h
(2) **Subsequent level(s) of analogy** — N2 dates can be subsampled from the N1 previous analogue dates, for example on moisture variables (here a moisture index consisting of the product of relative humidity at 850~hPa and total precipitable water) by means of the RMSE criterion.
(3) Corresponding **observed precipitation** is assigned to analogue dates
(4) The daily observed amounts of precipitation for the Ni resulting dates provide an **empirical conditional distribution**, considered as the probabilistic prediction for the target day.

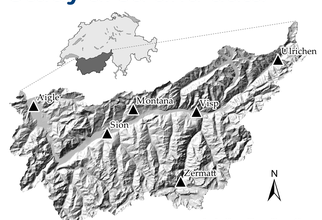


The moving time window approach

The MTW technique is used to find better analogue situations at **different hours of the day** rather than comparing the predictors at the same fixed hours. The target situation (the day to predict) is still the same as that in the conventional approach: a daily precipitation total between 06:00 and 30:00 UTC. The difference is that candidate situations are then considered at other hours by allowing a time shift: they are sought at the time step matching the **predictor time step**. The ERA-20C dataset was used here to test an MTW with 12-h, 6-h, or 3-h time steps, providing candidates that are two (12-h MTW), four (6-h MTW), or eight (3-h MTW) times as many as in the conventional approach.



Study area and data



Upper Rhone catchment in Switzerland. The precipitation time series were obtained from six automatic weather stations:

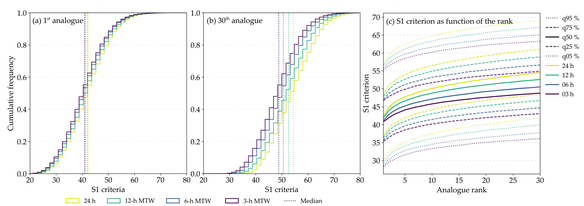
- Ulrichen
- Zermatt
- Visp
- Montana
- Sion
- Aigle

The results are presented for the Ulrichen station, but were very similar for all other stations.

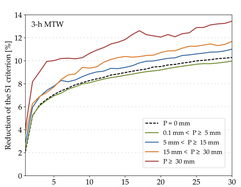
The data were available at an hourly time step for 29 years (1982 - 2010) and were also obtained at a standard daily time step of 06:00 to 30:00 UTC for 50 years (1961 - 2010). Predictors are provided by ERA-20C.

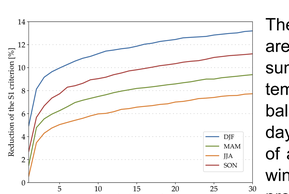
Influence on the selection of analogue dates

The analogy criterion (S1) decreased (= improved) with the MTW. The reduction is more important for **smaller MTW time steps** and higher ranks of the analogue => **accumulation of better analogue situations**.

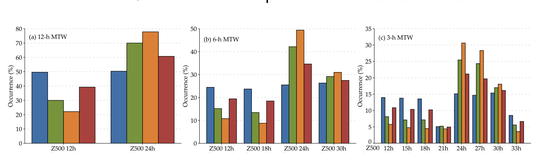


The MTW **improved** particularly the analogy for **days with higher precip.** (Fig right). These events are a consequence of atmospheric conditions with greater dynamics such as weather disturbances, which have well-marked temporal evolution and are less numerous in the archive. These situations can be more significantly improved when introducing an MTW.



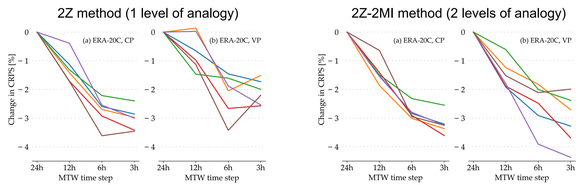


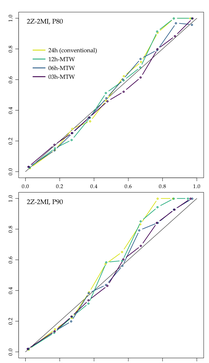
The improvements provided by the MTW are **more important in winter** than in summer (Fig. left). The new choice of the temporal window in winter was more balanced between the diff. hours of the day (Fig. bottom). => change in selection of a greater portion of the analogues for winter. This is likely attributed to more pronounced diurnal effects in summer.



Impact on the precipitation prediction

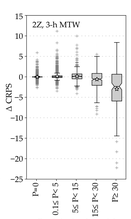
The changes in the **performance score** (CRPS) of the precipitation prediction are provided in the Figures below for the 2Z (1 level of analogy) and 2Z-2MI (2 levels of analogy) methods, respectively. The **MTW did improve the precipitation prediction** because the CRPS globally decreased for all stations, as if the length of the archive doubled.





Reliability was also improved (closer to the diagonal in Fig. left) by the MTW for the VP for both 2Z and 2Z-2MI methods and for the exceedance of all days percentiles 80% (P80) and 90% (P90). The improvements are more important for smaller MTW time steps.

As for the analogy criteria, the performance score was more improved (CRPS reduced) for days with **higher precipitation** (Fig. right). The MTW works as an inflation of the archive, as more candidate situations are available. This is first beneficiary for days with high precipitation amount.



Conclusions

The analogy and the prediction skill were improved by the MTW, as was the reliability of the prediction. Moreover, the improvements were greater for days with heavy precipitation. The improvements were found to be higher for MTWs with a smaller time step of 3 h. A 3-h MTW provides eight times more candidate situations (not fully independent). Thus, it can be considered as an inflation of the meteorological archive.