Statistical Downscaling

4) Analog(ue) Forecasts

- Analog methods (Lorenz, 1969; Zorita and von Storch, 1999) assume that similar local conditions occur under similar synoptic situations. They search synoptic analog situations in the past using a long historical record.
- Analog methods can generally maintain spatial coherence but they cannot predict values out of the observed range.
- The analogy may be defined using different metrics, such as the Euclidean distance of the predictor fields or pattern correlation.
- Different prediction configurations:
  - choose the best analog to the target day,
  - calculate a weighted average of a selection of analog days, with weights depending on their analogy,
  - a probability density function is built based on a selection of analog days, with probabilities given by their analogy to the target day

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5) Weather Generators

- Weather generators (WGs) are also known as stochastic weather models. They are statistical models that generate random sequences of local-scale weather with the temporal and spatial characteristics (such as the mean and variance) consistent with the observed weather (Wilks 1999; Tian et al. 2014).
- In statistical downscaling, the parameters of WGs are conditioned on large-scale atmospheric predictors or weather states.
- WGs can also be used to inflate variance. von Storch (1999) pointed out that the use of variance inflation or related approaches is not meaningful because large-scale predictors can not fully explain the variance of a local climate variable. Instead, von Storch (1999) advocated adding random small-scale variability.
- WGs have been used extensively in agricultural , ecosystem and hydrological impact studies to fill in missing data or produce long synthetic weather series from finite observation records.

Wilby et al. 2004

5) Weather Generators (Wilks 1999)

- Wilks (1999) used a weather generator to estimate daily station precipitation from daily precipitation in a coarse-resolution climate model.
  - Daily precipitation occurrence is governed by a 2-state (precipitation vs. no precipitation), first-order Markov chain, in which the probability of precipitation depends only on whether or not precipitation occurred on the previous day.
  - The Markov chain is defined by two parameters, climatological frequency of daily precipitation occurrence, π, and the lag-1 autocorrelation of the daily precipitation occurrence series, r.
  - Two other parameters are needed to determine the precipitation series, the mean daily nonzero precipitation amount, μ, and the corresponding variance, σ^2.
  - In summary, a precipitation time series is approximately determined by a four-parameter set (π, r, μ, σ^2)

5) Weather Generators (cont'd; Wilks 1999)

- What we have:
  a. the grid-point-level parameter set for the present climate from observation
  b. the station-level parameter set for the present climate from observation (each station is located within a grid-box-sized area)
  c. the grid-point-level parameter set for the future climate from climate predictions
- What we need:
  d. the station-level parameter set for the future climate (i.e., we will downscale from grid-box-sized area-average to individual stations)

(d) Can be estimated from (c) based on the relationship between (a) and (b), assuming that the modeled relationships between the area-averaged series and their constituent station series are the same as those observed relationships.

5) Weather Generators: Strengths and Weaknesses

- Strengths:
  - Production of large ensembles for uncertainty analysis or long simulations for extremes
  - Useful for temporal downscaling (such as generating sub-monthly or sub-daily information)
- Weaknesses:
  - Arbitrary parameter modification for future climate scenarios (Wilks, 1992).
  - Unanticipated effects to secondary variables of changing precipitation parameters

Wilby et al. 2004

Statistical Downscaling: limitations

- Statistical downscaling does not work well in regions where a strong relationship between the large-scale climate and regional climate does not exist, such as regions of complex topography.
- Statistical downscaling cannot capture relationships not present in history.
- Variables downscaled independent of one another may not follow first principles of meteorology (e.g. the relationship between temperature and relative humidity) and may result in physically implausible outcomes.
- The variance of the predictand is often underestimated in statistical downscaling (with the exception of weather generators). To address this issue, some studies inflated the anomaly by the ratio of the standard deviations of the observed and downscaled time series, and some studies represented the unresolved processes by adding noises.

See Fowler 2007

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