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CO	Confidential, only for members of the Consortium (including the Commission Services)	

D5.2 Assessment of the decadal-scale variations of precipitation extremes in ERA40 by comparison to observations in the Alpine region

WP5.4 Evaluation of extreme events in observational and RCM data

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Introduction

The purpose of this deliverable is to evaluate decadal-scale variations of precipitation extremes in the ERA40 reanalysis in the Alpine region. Due to the large bias in daily precipitation statistics of raw ERA40 precipitation data, a simple bias-correction scheme is used in order to reduce the ERA40 bias. The method corrects for biases in wet-day frequency and intensity. The bias-corrected ERA40 precipitation data shows good skill in capturing the variations of precipitation extremes on interannual to decadal time scales in the Alpine region.

Data and method

The observational dataset

The observations consist of mesoscale gridded fields of daily precipitation for a 1100 x 700 km domain of the European Alps and adjacent foreland regions (see domain in Figure 1). The precipitation analysis has a resolution of about 50 km (regular latitude-longitude grid with 0.5° resolution), was derived from a high-resolution rain-gauge network and it extends over 34 years (1966–1999). Details of the dataset and gridding procedure are given in Frei and Schär (1998).

Evaluation method

The evaluation of the ERA40 precipitation fields is based on selected summary statistics of daily precipitation. The diagnostics encompass the frequency of wet days (larger than 1 mm), the mean wet-day intensity, the 90% quantile of daily precipitation, and the maximum 5-day precipitation amount (see Table 1). All diagnostics are calculated for each grid point of the observational grid and then aggregated to mean values for three subregions. The three subregions (see Figure 1) cover the variability of the Alpine region and adjacent foreland areas with flat areas (region WEST), the northern rim of the main ridge (NALP) and a region with frequent heavy precipitation in Ticino Southern Switzerland (TIC). The three regions cover approximately the area of 6, 4 and 2 grid points (1.25° grid) of the reanalysis grid, respectively. For the current application the bias-correction method was calibrated on the 19 years of 1966–1978 and 1994–1999, the evaluation of the (remaining) bias is conducted for the 15 years of 1979–1993, and the evluation of the decadal-scale variations is carried out for the full period for which the observations are available (1966–1999).

Table 1: Diagnostic indices considered in the present analysis.

name	description
FRE	wet-day frequency
INT	wet-day intensity
Q90	90th percentile of wet-day amounts
X5D	maximum 5-day precipitation amount

Bias-correction method

The bias-correction method can be regarded as a simple precipitation downscaling technique which uses the large-scale reanalysis preciptation as a predictor for regional or local precipitation.

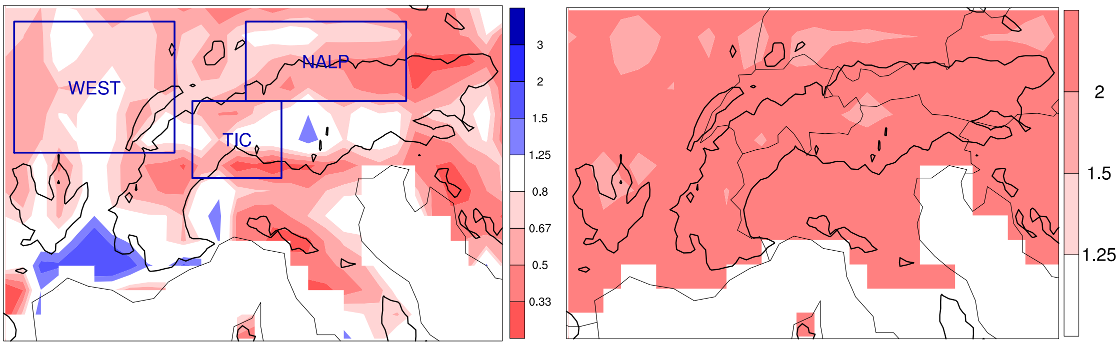

Figure 1: Wet-day threshold (left) and scaling factor for wet-day intensity (right) for ERA40, as determined for the 19-yr calibration period 1966–1978, 1994–1999. The left panel also illustrates the subregions used in our analysis.

The downscaled precipitation series is obtained by a correction of the precipitation series from the reanalysis grid point closest to the regional/local grid point. The original method, as proposed by Widmann et al. (2003) for monthly precipitation, applies a spatially varying, time-independent, scaling of the reanalysis precipitation to compensate for its long-term bias. The recent extension to the daily time scale by Schmidli et al. (2006), the so called local intensity scaling method, involves a more complex, but still time-independent, bias correction procedure, where the biases in wet-day frequency and wet-day intensity are treated separately.

The calibration of the local intensity scaling method consists of two steps. First, a model wet-day threshold P^m_{WDT} is determined from the daily reanalysis precipitation series such that the threshold exceedance matches the wet-day frequency in the observations. Figure 1 depicts the field of ERA40 wet-day thresholds. The threshold is mostly close to or smaller than $1\ \mathrm{mm}$ (P^o_{WDT}), indicating that ERA40 simulates too few days with precipitation above $1\ \mathrm{mm}$ compared to the observed grid-point time series.

In a second step, a scaling factor s is calculated from the wet-day intensities by

$$s = \frac{\langle P^o : P^o \geq P^o_{\mathrm{WDT}} \rangle - P^o_{\mathrm{WDT}}}{\langle P^m : P^m \geq P^m_{\mathrm{WDT}} \rangle - P^m_{\mathrm{WDT}}}. \tag{1}$$

Here P^o and P^m are daily precipitation values of the observations and the reanalysis, respectively, and the angle brackets indicate long-term averages. Hence, s is essentially the ratio of wet-day intensities between observations and the reanalysis. In the Alps, the intensity scaling factor s is mostly larger than 2 for ERA40 (Figure 1), indicative of the substantial underestimation of precipitation intensity by ERA40. For further details on the downscaling method and a comparison of bias-corrected ERA40 data with RCMs see Schmidli et al. (2006).

Evaluation

The annual cycle

Figure 2 compares the annual cycle of the raw and bias-corrected ERA40 reanalysis against observations. For all regions and diagnostics, the bias correction accomplishes a substantial improvement compared to the unadjusted reanalysis. It compensates for the substantial dry bias of ERA40

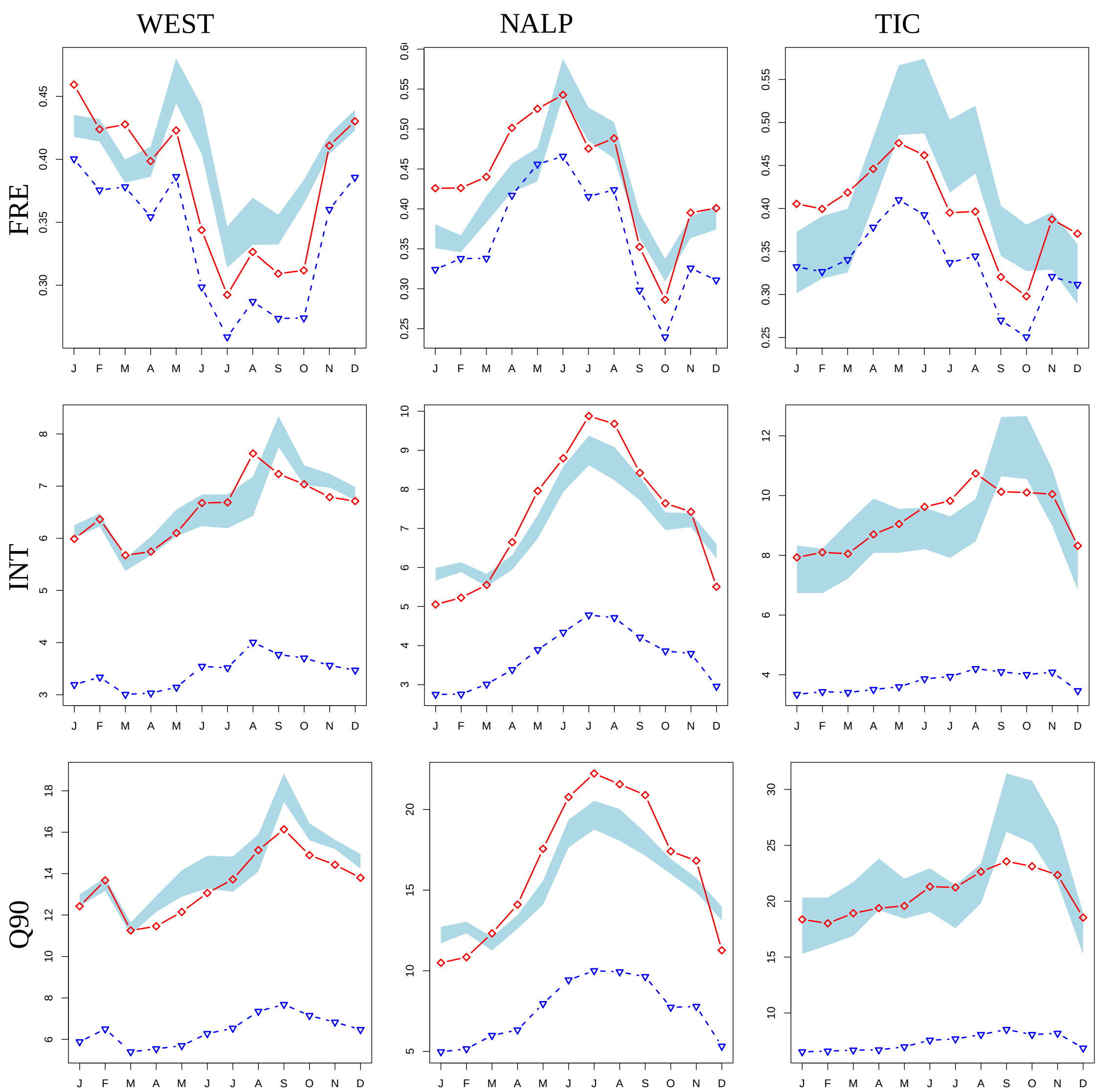

Figure 2: Annual cycle of gridpoint precipitation statistics averaged over the three subregions (see Fig. 1) for the local intensity scaling (LOCI, solid), the reanalyses (dashed), and the observations (OBS, shaded). Results are valid for the evaluation period 1979–1993.

in precipitation frequency and intensity. The results for the two larger regions (WEST, NALP), for which the bias-corrected data are close to the observed values, are particularly convincing. However, the limitations of a large-scale reanalysis become evident for the smaller region (TIC). Even after bias correction the autumn heavy precipitation peak (in INT and Q90) is essentially missing. Apparently, the reanalysis is too coarse to represent the channeling of southerly airflows and precipitation enhancement in the regional indentation of the Alpine ridge. Nevertheless, the generally accurate representation of the annual cycle by the bias-corrected reanalysis attests to the quality of ERA40 in reproducing the precipitation statistics in the Alpine region, despite large biases in the raw output. Note that no seasonal information is included in the bias correction.

Interannual to decadal-scale variations

Figure 3–6 shows time series of the diagnostics for unadjusted and bias-corrected ERA40 output and the observations. For the largest region (WEST) the bias-corrected ERA40 reanalysis closely follows the observations in all seasons, except summer. Interannual variations, as well as decadal-scale trends are represented well. See for instance the positive trend in X5D between 1970 and 1983 in winter, or the two periods of positive trends in X5D in spring (1970–1989, 1990–2000). In summer, on the other hand, there is a spurious negative trend in the reanalysis X5D not supported by the observations. Similar results are found for the northern Alps region (NALP) with in general somewhat lower correlations than for region WEST (except for X5D in summer). For the smallest region (TIC) the correspondence with the observations is generally lower. While the represenation of interannual to decadal-scale variations is still quite good for precipitation frequency (except for summer), it is less skillful for the other diagnostics. While the correlation can still be quite high (e.g. X5D in spring), the year-to-year variability is often significantly underestimated. Note also the spurious negative trends in the reanalysis in summer for the smallest region.

Conclusion

The representation of interannual to decadal-scale variations of precipitation statics in the Alpine region by ERA40 has been assessed. It was found that in the Alpine region the ERA40 reanalysis tends to slightly underestimate precipitation frequency, especially during the summer season, and to substantially underestimates precipitation intensity throught the year. However, both errors can be corrected to a large extent using a simple bias-correction method. The adjusted reanalysis data represents the interannual to decadal-scale variations quite successfully, even for extremes such as the maximum 5-day precipitation amount. The correspondence with observations is particularly high for the winter season and for the larger two regions. The correspondence is lowest for the Ticino region which is most heavily influenced by mesoscale processes.

References

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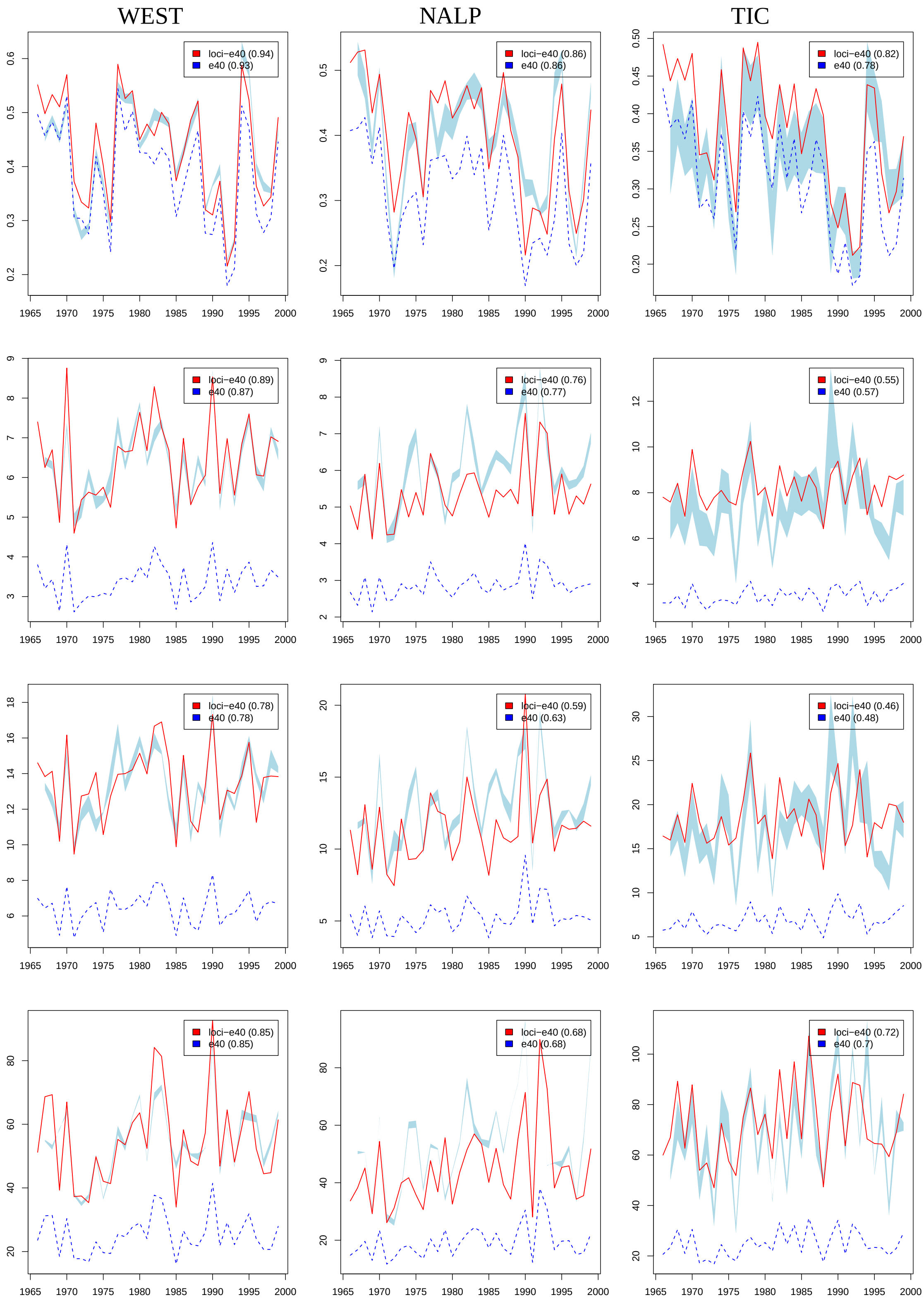

Figure 3: Time series of the diagnostic indices (FRE, INT, Q90, and X5D from top to bottom) for winter, for the period 1966–1999, for the bias-corrected reanalysis (solid), the unadjusted reanalysis (dashed) and the observations (shaded). In parenthesis the anomaly correlation.

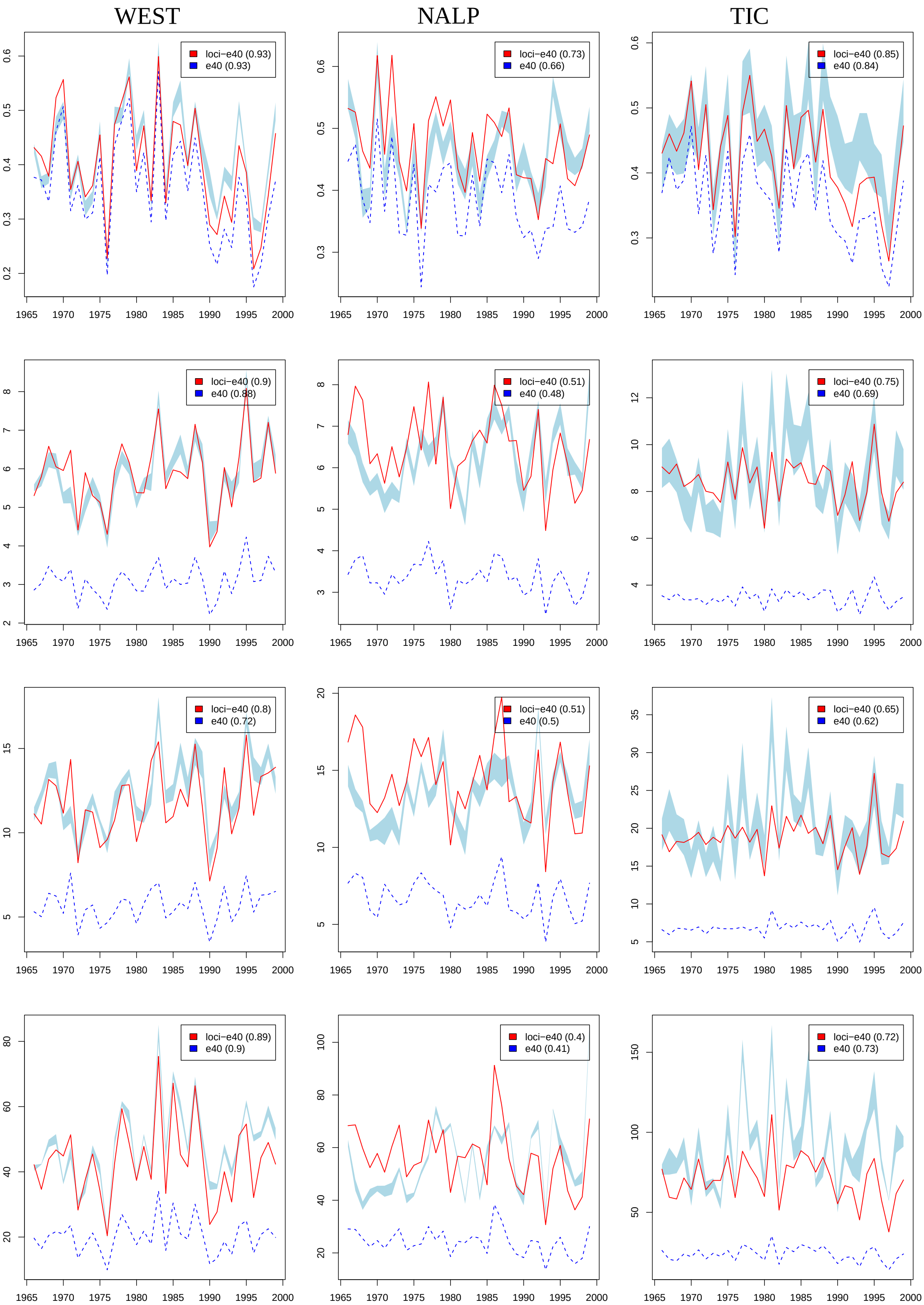

Figure 4: Time series of the diagnostic indices (FRE, INT, Q90, and X5D from top to bottom) for spring, for the period 1966–1999, for the bias-corrected reanalysis (solid), the unadjusted reanalysis (dashed) and the observations (shaded). In parenthesis the anomaly correlation.

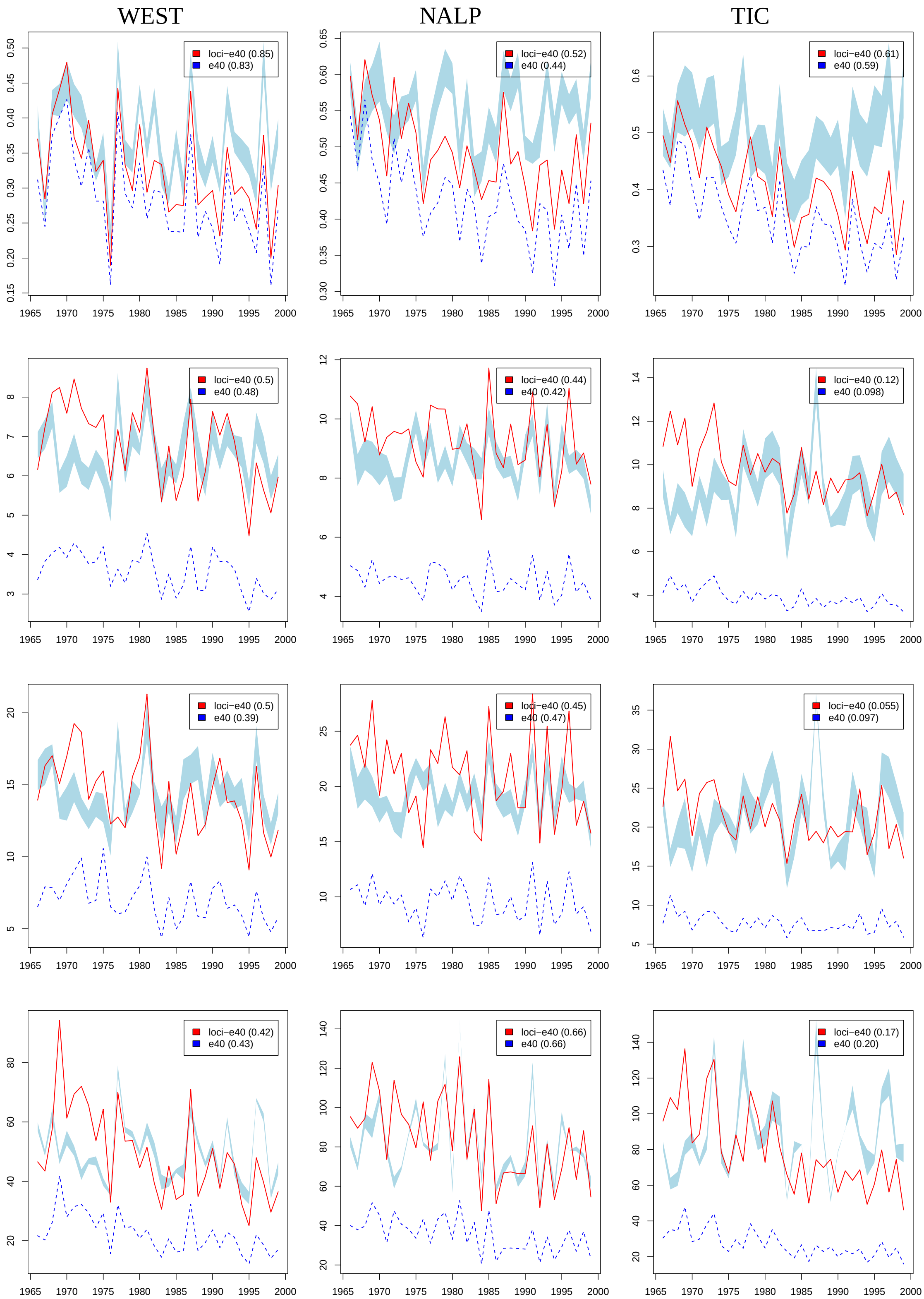

Figure 5: Time series of the diagnostic indices (FRE, INT, Q90, and X5D from top to bottom) for summer, for the period 1966–1999, for the bias-corrected reanalysis (solid), the unadjusted reanalysis (dashed) and the observations (shaded). In parenthesis the anomaly correlation.

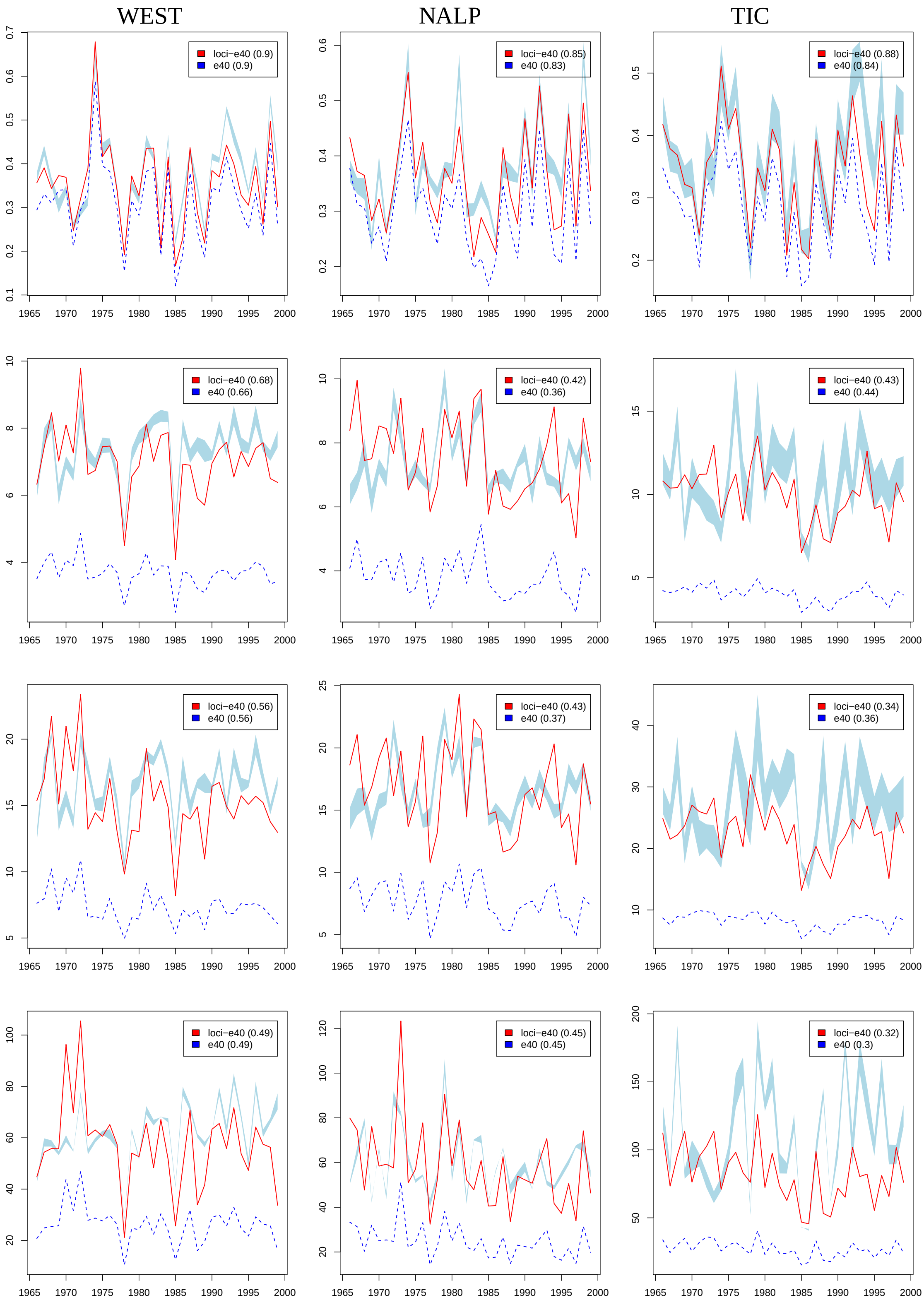

Figure 6: Time series of the diagnostic indices (FRE, INT, Q90, and X5D from top to bottom) for autumn, for the period 1966–1999, for the bias-corrected reanalysis (solid), the unadjusted reanalysis (dashed) and the observations (shaded). In parenthesis the anomaly correlation.