Hydrol. Earth Syst. Sci. Discuss., 12, C421–C424, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C421/2015/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Nonstationarity of low flows and their timing in the eastern United States" *by* S. Sadri et al.

F. Serinaldi

francesco.serinaldi@ncl.ac.uk

Received and published: 5 March 2015

I have just received the alert of this paper, and, as the title is very attractive, I have had a quick look. This is not a review and I will not discuss the empirical results reported in the paper just because they simply result from the methodology (the couple of pages of Sections 2.3.1, 2.3.2), which in turn, in my opinion, should carefully be reconsidered. I also apologize in advance for mentioning some of my own papers in the following. After viewing/reading hundreds papers dealing with the application of Mann-Kendall (MK), Pettitt and similar tests to check for "nonstationarity", I think that this is the right time to go back and reflect on the meaning of words and statistical tools, and how they are used in hydrological analyses. About "nonstionarity", it is worth mentioning that this

concept does not refer to time series but to models and corresponding processes. In this respect, a discussion can be found for instance in

Koutsoyiannis D, Montanari A, Negligent killing of scientific concepts: the stationarity case Hydrol Sci J (2014) http://dx.doi.org/10.1080/02626667.2014.959959,

Montanari A, Koutsoyiannis D, Modeling and mitigating natural hazards: Stationarity is immortal! Water Resour Res, 50 (12) (2014), pp. 9748–9756,

Serinaldi F, Kilsby CG. Stationarity is undead: Uncertainty dominates the distribution of extremes. Advances in Water Resources 2015a, 77, 17-36,

and references therein. Sentences such as "Visual inspection of the time series and the changes therein can be very helpful in determining stationarity. A time series plot of a stationary series should show oscillation around some fixed level, a phenomenon called reversion to the mean (Ruppert, 2011)." reflect a more and more widespread misconception which comes from the introduction of econometrics concepts/results in hydrology, without considering the essential differences, in terms of underlying process dynamics and available sample size, between financial data (e.g. high frequency trading data) and a few tens of hydrological annual minima, maxima, or slightly longer over-, under-threshold observations. In the hydrological context (especially for the data used in this study), talking about mean reversion is purely speculative as the data are not enough to support conclusions about this, simply because the estimation of the moments is high uncertain and convergence toward the "true" mean can be much slower than expected. See e.g.

Lombardo F, Volpi E, Koutsoyiannis D, Papalexiou SM, Just two moments! A cautionary note against use of high-order moments in multifractal models in hydrology, Hydrol. Earth Syst. Sci., 18, 243–255, 2014 www.hydrol-earth-syst-sci.net/18/243/2014/

and the discussion in Section 6.2 in Serinaldi and Kilsby (2015a, mentioned above).

Now, even though the Authors would prefer following the mainstream beliefs about “nonstationarity”, the decomposition procedure proposed in Section 2.3.2 shows some technical problems. MK and Pettitt are devised to check monotonic trends and abrupt changes under “iid” conditions, and the literature usually overlooks that the Pettitt test is more sensitive than MK to the presence of autocorrelation, as is discussed in

Serinaldi F, Kilsby CG. The importance of prewhitening in change point analysis under persistence. Stochastic Environmental Research and Risk Assessment 2015b.

Thus, using Pettitt on series exhibiting serial correlation is even more dangerous than applying MK. In a nutshell, there is interplay between possible “deterministic” trends and serial correlation. Therefore, a suitable analysis requires (1) the choice of a model for the possible deterministic trend, (2) the choice of suitable model for the autocorrelation structure (note that the usual small sample sizes often make it not easy to be recognized), (3) a simultaneous treatment (estimation) of both models, (4) a careful treatment of several sources of bias affecting the autocorrelation and other parameters (see e.g. Serinaldi and Kilsby 2015b, above and references therein). All these steps have their own uncertainty, which make test results often qualitative rather than quantitative. Moreover, after detection of possible significant trends, attribution is a key aspect: since the detected trends should be deterministic they need to be clearly recognizable and quantifiable. Indeed determinism (as intended in this context) refers to processes that evolve over time scales such that their evolution is predictable with no (or negligible) uncertainty (over temporal horizons of interest). See e.g. the discussion in

Koutsoyiannis, D.: HESS Opinions "A random walk on water", Hydrol. Earth Syst. Sci., 14, 585-601, doi:10.5194/hess-14-585-2010, 2010.

In this respect, attribution via USGS flags should be considered with great care as sometimes it is not sufficient to explain detected changes (see e.g. Section 6.2 in Serinaldi and Kilsby, 2015a, and references therein).

Finally, please consider to account for spatial correlation (even if time series have dif-

ferent length), as it can strongly affect the test outcome in a multiple testing exercise. See e.g. Douglas et al. 2000 (mentioned in the text, but maybe a bit overlooked in the analyses) or

Guerreiro SB, Kilsby CG, Serinaldi F. Analysis of time variation of rainfall in transnational basins in Iberia: abrupt changes or trends?. International Journal of Climatology 2014, 34(1), 114-133,

and references therein. Also in this case, spatial and temporal correlation can interact, and should carefully be handled. En passant, I would suggest using bootstrap procedures to account for cross-correlation, as it can be shown that some approaches using variance correction factors (available e.g. for MK) or false discovery rate factors (recently applied in the hydrological literature) are strongly biased and do not provide suitable corrections.

Sincerely,

Francesco Serinaldi

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 2761, 2015.