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# SUPPLEMENTARY INFORMATION FOR “A REASSESSMENT OF THE IMPACT OF TEMPERATURE CHANGE ON EUROPEAN CONFLICT DURING THE SECOND MILLENNIUM CE USING A BAYESIAN TIME-SERIES MODEL”

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A PREPRINT

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## 1 Autocorrelation in Conflict

The historical record of European conflict from 1000–2000 CE contains significant temporal autocorrelation. This is a common feature of conflict records that scholars have long been aware of (Richardson, 1944), and one that need special consideration in a statistical treatment of trends in such records. The plot in Fig. 1 shows this temporal autocorrelation.

## 2 Convergence Diagnostics

With any MCMC-based Bayesian analysis it is important to ensure that the posterior distributions have been appropriately sampled. We used a combination of visual inspection (e.g., Fig. 2) and a standard diagnostic called the Geweke statistic (Geweke, 1992). The Geweke statistic is essentially a t-test that compares the distribution of posterior MCMC samples from the first 10% of a given MCMC chain to the last 50% of the same chain. If the test finds no significant difference between the means of those distributions, then the MCMC algorithm has produced a long-run stationary sample of the relevant marginal posterior distribution. A stationary MCMC chain—often considered to have “converged”—is likely an unbiased sample of the relevant posterior. The following table shows the Geweke statistics for the MCMC chains of the parameters for each of the three models we evaluated. The statistics indicate that the MCMC algorithm converged to unbiased samples of the posteriors in each case, further supporting the visual appearance of convergence in the relevant MCMC trace plots.

## References

- Geweke, J.  
1992. Evaluating the Accuracy of Sampling-Based Approaches to the Calculation of Posterior Moments. In *Bayesian Statistics*, J. M. Bernardo, J. O. Berger, A. P. Dawid, and A. F. M. Smith, eds., Pp. 169–193. Oxford: Clarendon Press.
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1944. The Distribution of Wars in Time. *Journal of the Royal Statistical Society*, 107(3/4):242–250.

**Annual Conflict Autocorrelation**

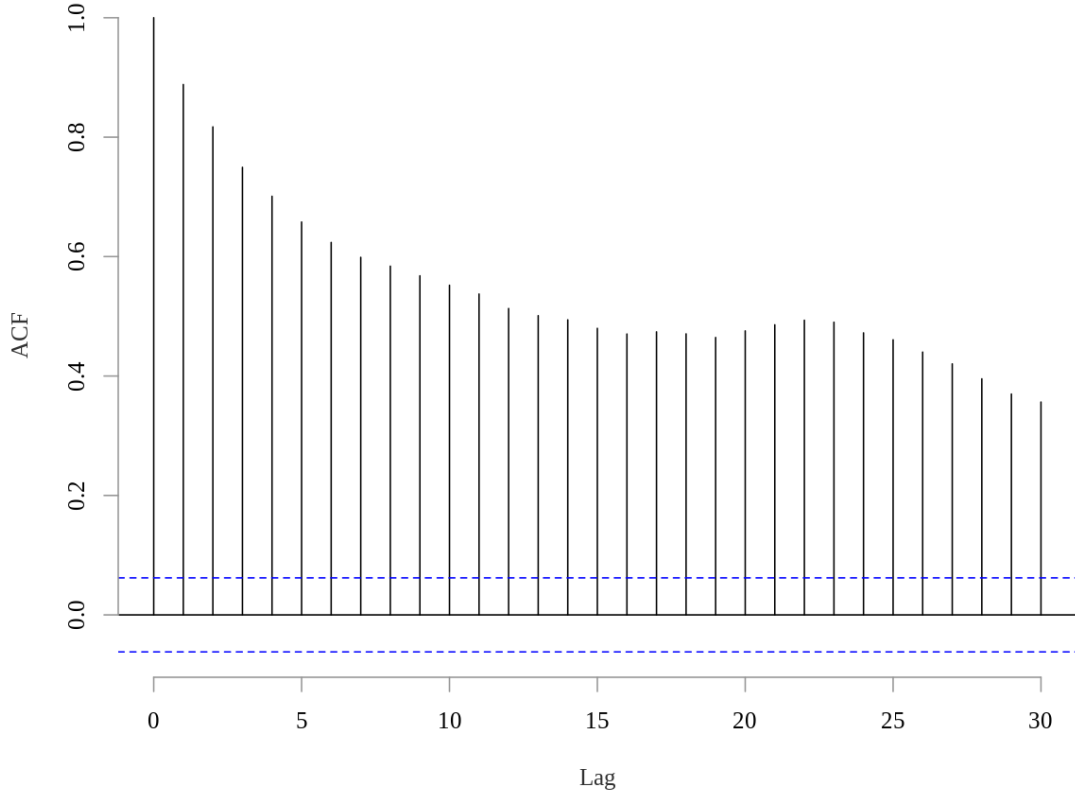


Figure 1: Autocorrelation in European conflict from 1000–2000 CE.

Table 1: Geweke statistics for MCMC chains of the parameters for each of the three models we analyzed. Each row contains statistics for a given model while the columns contain statistics for a given parameter MCMC chain. The statistics are reported in standard deviations of the standard normal distribution (rounded to the second decimal place), which means that only values larger in magnitude than approximately 2.5 would fall outside the 99% confidence interval. Since none of the values do, we concluded the MCMC chains were stationary for the parameters in each model, which in turn led us to believe the relevant posterior distributions were appropriately sampled.

Temperature Reconstruction	Intercept	Temp.	$\lambda_0$	$\rho$	$\sigma$
Buntgen	1.44	0.22	0.46	-0.33	2.14
Glaser	-0.10	0.72	0.20	-1.27	1.40
Luterbacher	0.31	-0.17	-0.56	1.39	-1.71
Mann	-0.41	1.29	-0.87	-0.23	-1.19

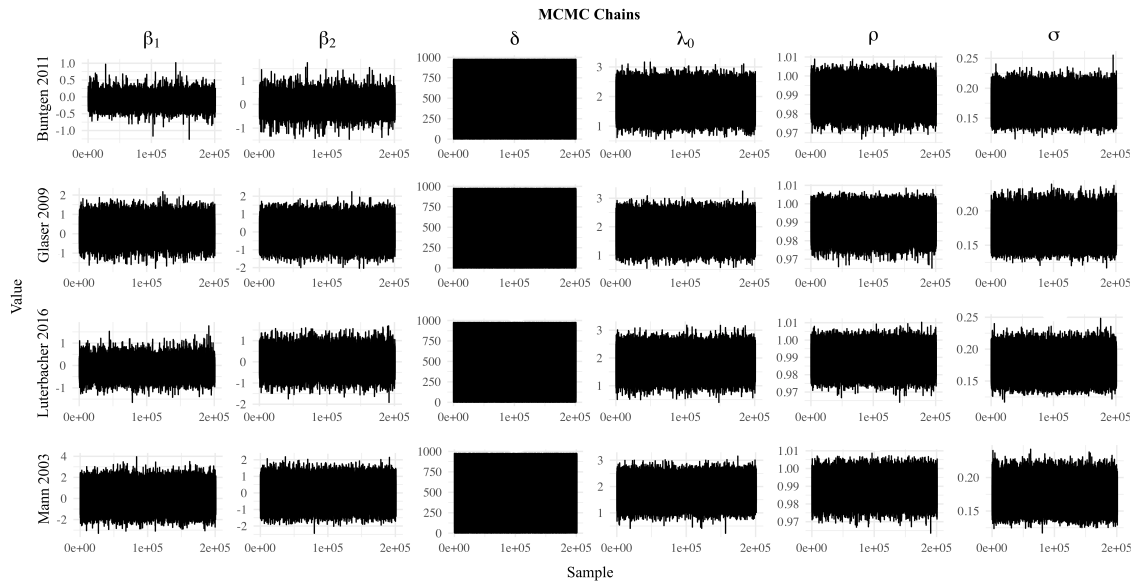


Figure 2: MCMC Chains