Calibration Concordance for Astronomical Instruments via Multiplicative Shrinkage

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Data

Abstract (Mandatory)

Calibration data are often obtained by observing several well-understood objects simultaneously with multiple instruments, such as satellites for measuring astronomical sources. Analyzing such data and obtaining proper concordance among the instruments is challenging when the physical source models are not well understood, when there are uncertainties in “known” physical quantities, or when data quality varies in ways that cannot be fully quantified. Furthermore, the number of model parameters increases with both the number of instruments and the number of sources. Thus, concordance of the instruments requires careful modeling of the mean signals, the intrinsic source differences, and measurement errors. In this paper, we propose a log-Normal hierarchical model and a more general log-t model that respect the multiplicative nature of the mean signals via a half-variance adjustment, yet permit imperfections in the mean modeling to be absorbed by residual variances. We present analytical solutions in the form of power shrinkage in special cases and develop reliable MCMC algorithms for general cases. We apply our method to several data sets obtained with a variety of X-ray telescopes such as Chandra. We demonstrate that our method provides helpful and practical guidance for astrophysicists when adjusting for disagreements among instruments.

Availability (Mandatory)

All code and partial real will be publicly available on Github. A fraction of real data won’t be publicly available upon request of astrophysics collaborators.

Description (Mandatory if data available)

The real data used in the manuscript are compiled by two of the co-authors, thus they own permission of the data. The data, together with full descriptions of its format and usage, will be available in our Github folder upon acceptance of the paper. The link is here: https://github.com/astrostat/Concordance

Optional Information (complete as necessary)

Code

Abstract (Mandatory)

All code (Python) that can reproduce all the results presented in the paper are available at https://github.com/astrostat/Concordance.

Description (Mandatory)
The delivery is a Python module “CalConcordance”, as mentioned in the paper. The Python code included in the module implements all the algorithms proposed in the paper. It will be available at Github folder https://github.com/astrostat/Concordance.

Optional Information (complete as necessary)

Instructions for Use

Reproducibility (Mandatory)
The Github folder https://github.com/astrostat/Concordance contains detailed code for reproducing all the results and figures presented in the paper.

Replication (Optional)

Notes