Practice on Estimating Beta & Mmax

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Contents

Motivation

❖ Target Parameters: Beta & Mmax

- ➢ Gutenberg-Richter relation

$$\log N = a - bM \text{ or } \ln N = \alpha - \beta M$$

- ➢ P.d.f. of magnitude: doubly truncated exponential function

$$f(m) = k\beta e^{-\beta(m-m_0)},$$

where $k = [1 - e^{-\beta(m_1-m_0)}]^{-1}$, $m_1 = m_{max}$, $m_0 = m_{min}$

❖ Inter-linkage of Beta & Mmax

- ➢ They are linked each other, if m_{max} is to be estimated by using
  - Seismic catalog
  - Doubly truncated exponential function
- ➢ Estimating one needs information of the other

Data Preparation

❖ Monte-Carlo Simulation

- ➢ Mmin=3.0, Mmax=7.0
- ➢ b=1.0 → beta=2.306…

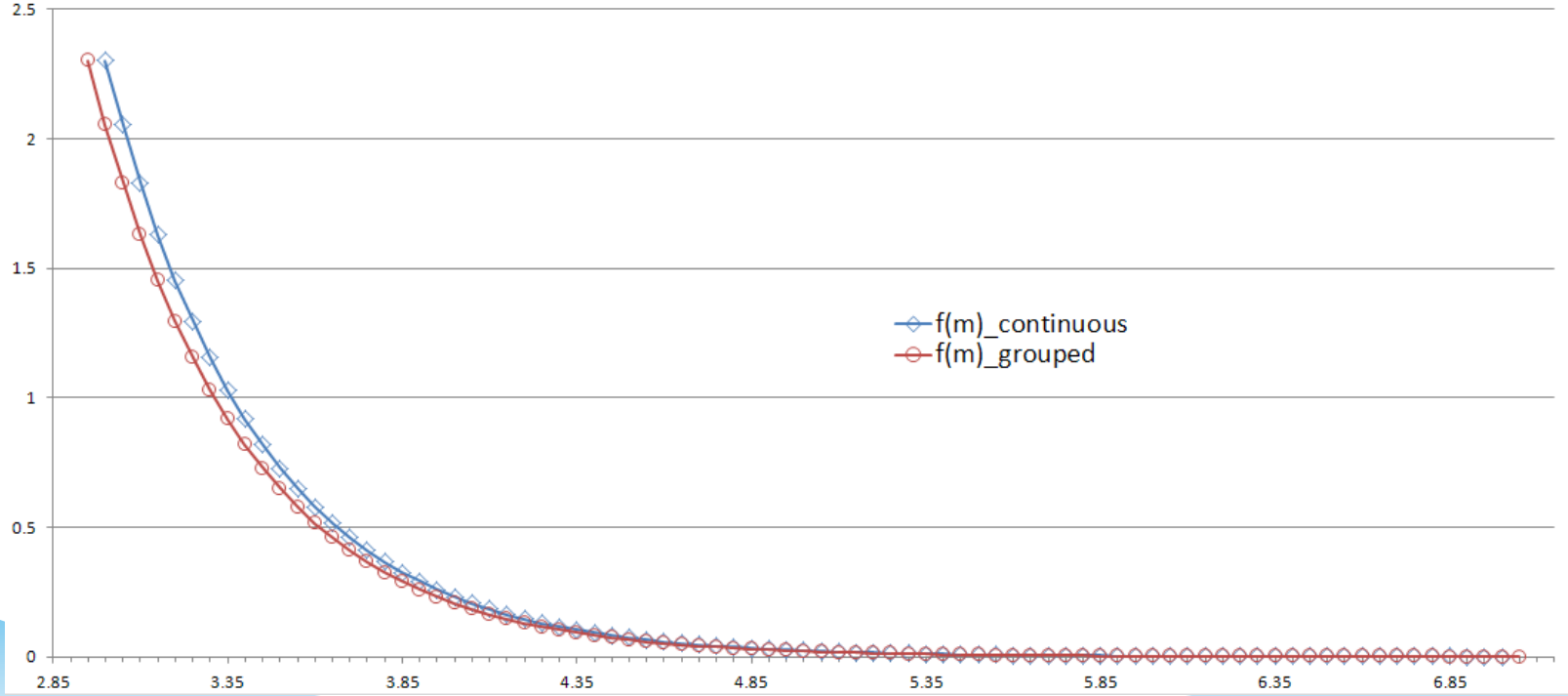
❖ Sample Sizes

- ➢ For seismic catalogs of 100 ~ 1,500 events
  - ▪ Estimate beta and Mmax for every 100 events
- ➢ For seismic catalogs of 2,000 ~ 15,000 events
  - ▪ Estimate beta and Mmax for every 1,000 events

Data Preparation

❖ Adjustment for Magnitude Grouping

- ➢ Width of magnitude interval: ΔM=0.1
- ➢ Mmin → Mmin-ΔM/2 = 2.95
- ➢ Mmax → Mmax+ΔM/2 = 7.05
- ➢ b: unchanged



Data Preparation

- **Adjustment for Magnitude Grouping**
  - Wic
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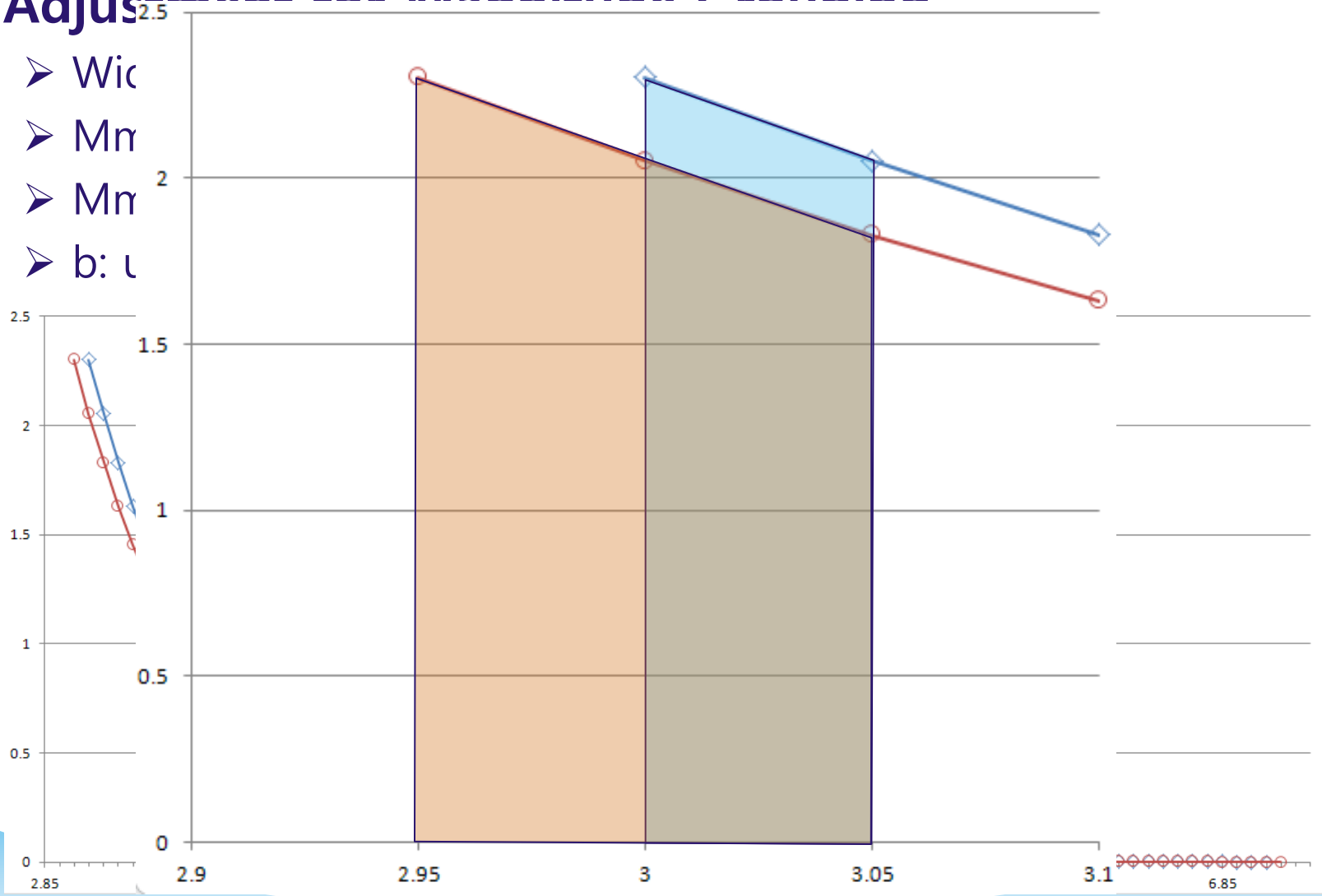
  - Mn
  - b: u



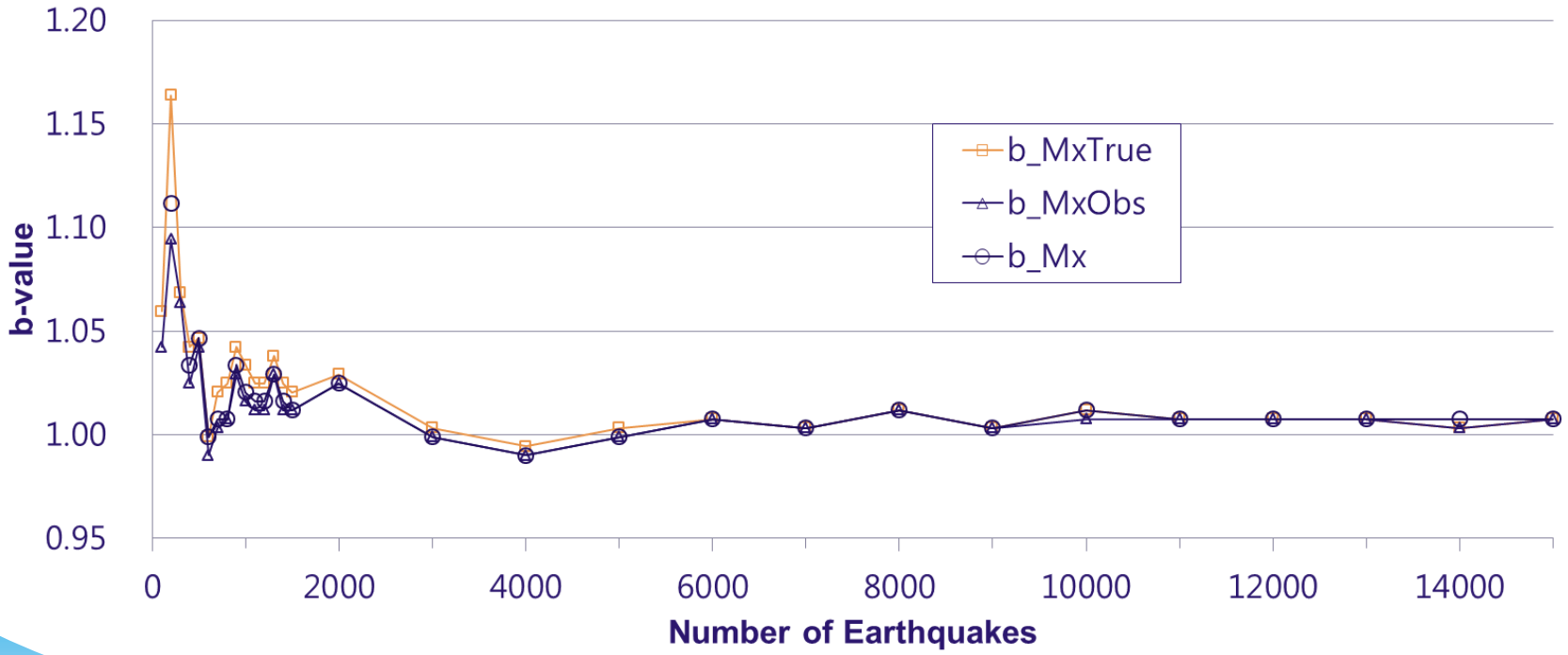
Estimation Methods

- **Estimating Beta: Weichert (1980, BSSA)**
  - An equal observation period
  - $\Delta M = 0.1$
- **Estimating Mmax: Case I of Kijko (2004, P&A Geophy.)**
  - Truncated exponential distribution assumed
- **Combined Estimation of Beta & Mmax**
  - Iterated estimation starting with estimating beta
    - Obseved Mmax as an initial guess
  - Estimating methods are the same as above

Results

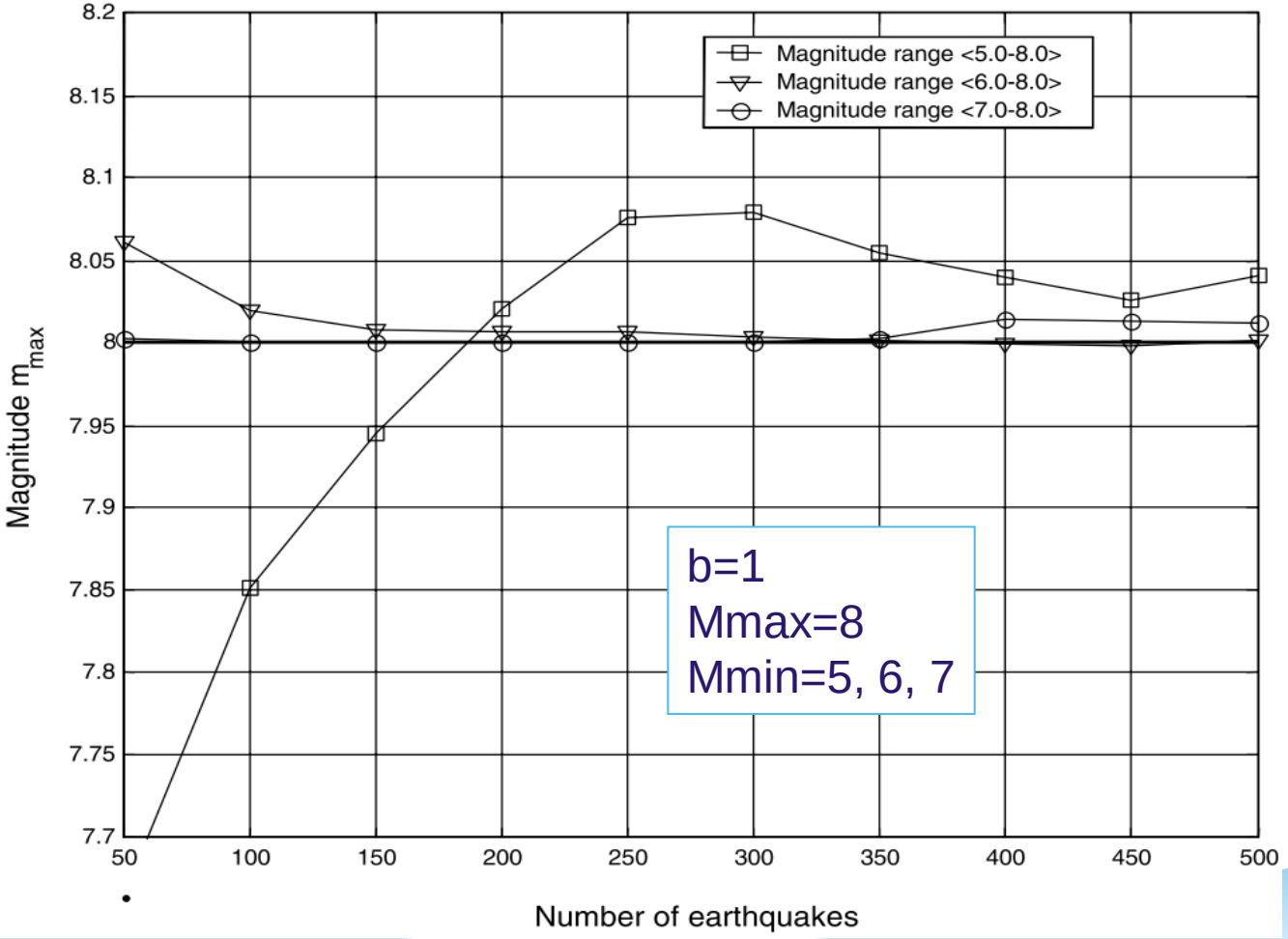
❖ Estimating Beta

- ➢ Effect of M_{max}^{true} is insignificant
  - Use of M_{max}^{obs} yields a beta estimate accurate enough
- ➢ Beta estimation is stable for small sample size, i.e. 1000 events



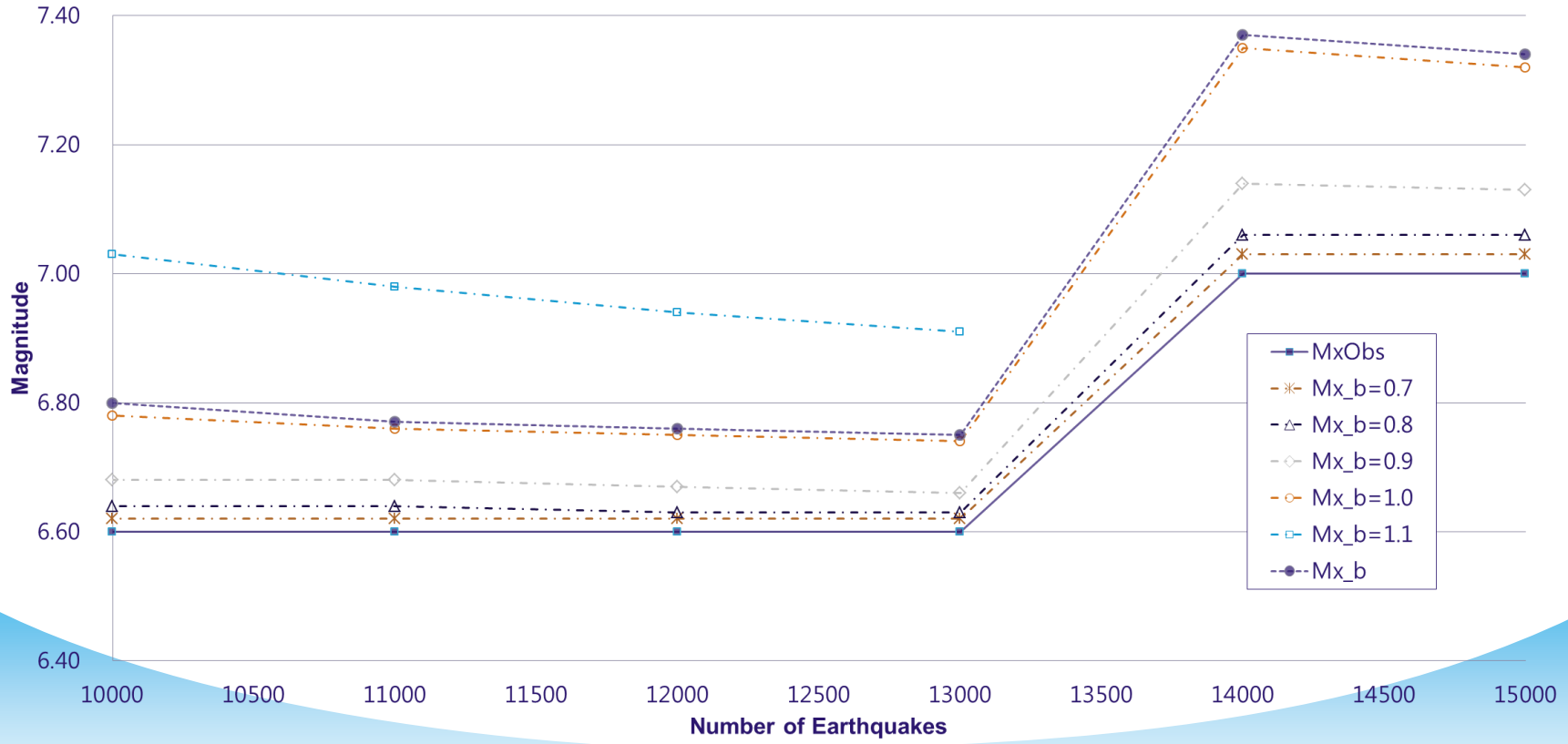
❖ Estimating Mmax

➢ Effect of sample size (Kijko, 2004, P&A Geophy.)



Estimating Mmax (continued)

- It is significantly dependent on BETA values
- Combined estimation yields reasonable estimates
- Mmax is over-estimated, if $M_{max}^{obs} = M_{max}^{true}$ (= Mmax)



Summary

- **Estimate Beta first,**
  - M_{max}^{obs} can effectively replace the unknown M_{max}^{true}
- **Then Estimate Mmax**
- **Better Estimate by Iterative scheme**
  - Starting with beta estimation first

Thank You!