Using merror 2.0 to Determine Measurement Bias and Imprecision

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Introduction

- Goal: compare devices, determine *lack of agreement* of measurements (X)
- All n items measured by all $N>2$ devices
- Measurements likely contaminated by random error (ϵ) and distorted by bias

Measurement Error Theory

- Device i distorts "true value" μ_j of item j:
  - $X_{ij} = \alpha_i + \beta_i \mu_j + \epsilon_{ij}$ with $\Pi\beta_i=1$
  - $\mu_j \sim N(\bar{\mu},\sigma^2)$ – can be random or fixed
  - $\epsilon_{ij} \sim N(0,\sigma_i^2)$
  - α_i and β_i describe *bias* of device i
  - σ_i describes *imprecision* of device i

merror Version 2.0

- merror.pairs – compare all devices
- ncb.od – determine *relative bias* and *imprecision* using maximum likelihood
- lrt – likelihood ratio test for *scale bias*
- cplot – plot calibration curve

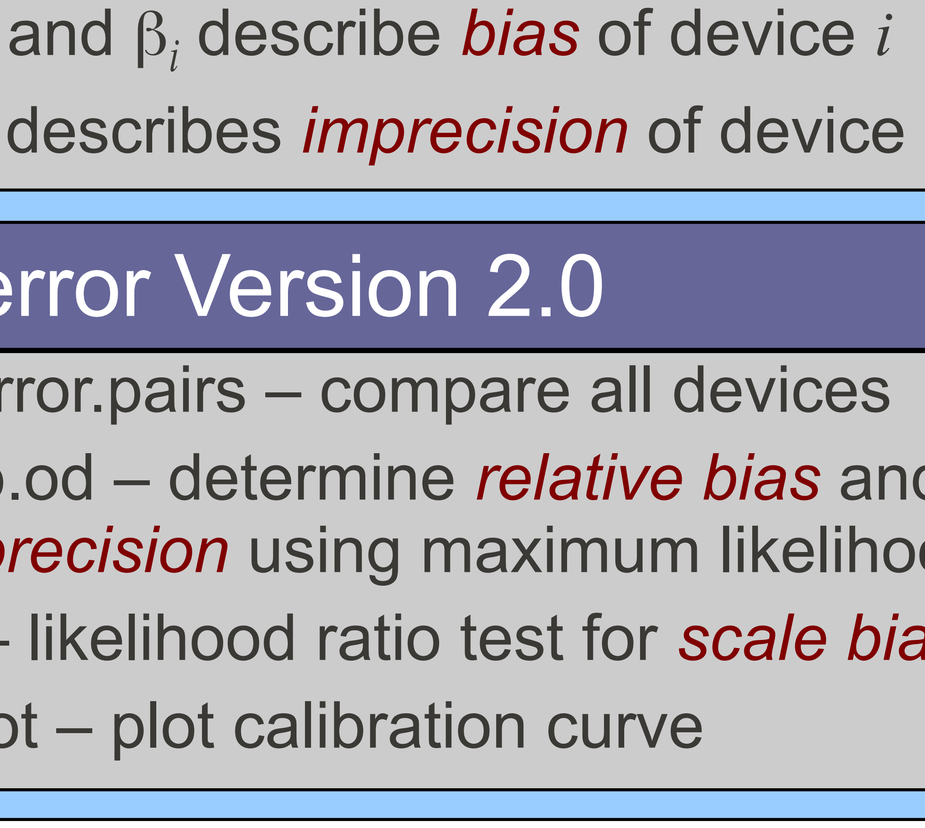

Figure 1. merror.pairs plot showing all pairwise comparisons – same range for all axes.

Install & Load merror

```
> install("merror")
> library(merror)
```

Some Data

```
> data(pm2.5) # Airborne particulate measurements
> head(pm2.5,3)
  ms.conc.1 ws.conc.1 ms.conc.2 ws.conc.2   frm
1  43.15607  42.79406 43.643504  40.97494 41.25
2  22.98748  18.73933 23.709867  21.72307 24.24
3  10.23405  10.16256  9.952063  10.83095 10.64
```

Analysis Using merror 2.0

```
> merror.pairs(sqrt(pm2.5)) # Figure 1
> round(ncb.od(sqrt(pm2.5)$sigma.table,3)[,c(1,2,5,6,10,11,12)]
           n sigma alpha.ncb  beta    lb    ub bias.adj.sigma
ms.conc.1 77 0.136     0.097 0.973 0.107 0.188         0.140
ws.conc.1 77 0.157     0.037 0.984 0.127 0.205         0.159
ms.conc.2 77 0.290     0.047 0.973 0.246 0.356         0.299
ws.conc.2 77 0.276     0.092 0.964 0.232 0.339         0.286
frm       77 0.289    -0.306 1.113 0.245 0.352         0.260
Process   77 1.239        NA    NA 1.069 1.472            NA
> lrt(sqrt(pm2.5)) # Annotated output - p<0.05 => scale bias
$lambda
[1] 21.72197
$df
[1] 4
$p.value
[1] 0.0002276429
> cplot(sqrt(pm2.5),1,5,regress=TRUE) # Figure 2
```

Figure 2. cplot showing the calibration curve for sqrt(frm) and sqrt(ms.conc.1) with regression lines for comparison only.