Quantitative drug sensitivity scoring

Statistical report

My-Luong Vuong, Erwin Dreesen 11 June 2024

# Data description

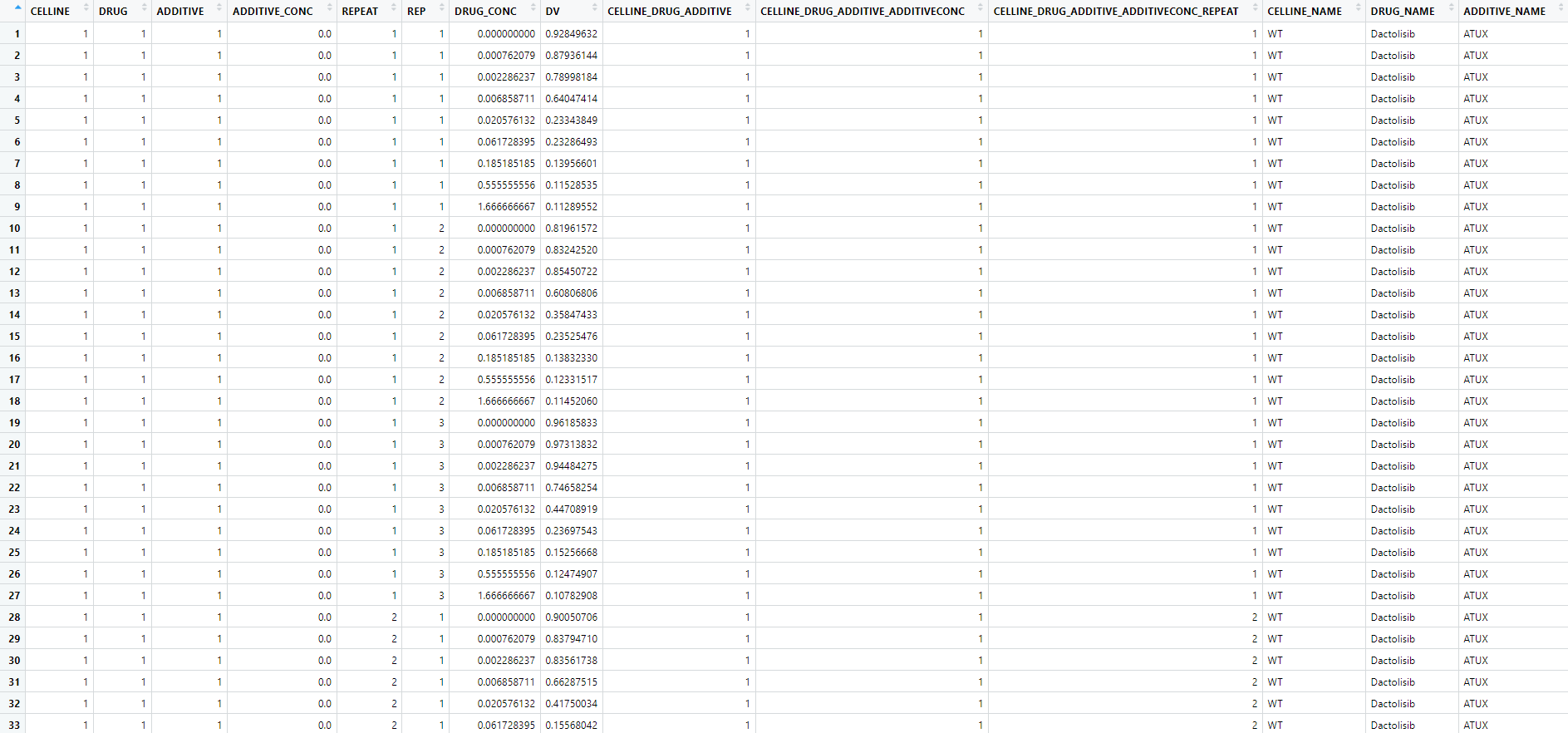
Data items

* CELLINE [integer]
  + 1: Wild Type (WT)
  + 2: R183W (Mutant)
* DRUG [integer]
  + 1: Dactolisib
  + 2: Erlotinib
* ADDITIVE [integer]
  + 1: ATUX
* ADDITIVE\_CONC [numeric]
  + ATUX: 0, 3, 4.5, 6 µM
* REPEAT [integer]
  + Inter-day variability; 3-4 experimental repeats (days)
* REP [integer]
  + 1, 2, 3
  + Within-day variability; 3 replicates per 96-well plate
* DRUG\_CONC [numeric]
  + Dactolisib: 0, 0.00076, 0.00229, 0.00686, 0.02058, 0.06173, 0.18519, 0.55556, 1.66667 µM
  + Erlotinib: 0, 0.02667, 0.08002, 0.24005, 0.72016, 2.16049, 6.48148, 19.44444, 58.33333 µM
* DV [numeric]
  + Dependent variable (Y-axis)
  + Cell viability
* CELLINE\_DRUG\_ADDITIVE
  + Option 1 for Level 1 clustering
  + 2 cell lines \* 2 DRUGs \* 1 ADDITIVE = 4 clusters
* CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC
  + Option 2 for Level 1 clustering
  + 2 cell lines \* 2 DRUGs \* 1 ADDITIVE \* 4 ADDITIVE concentrations = 16 clusters
* CELLLINE\_DRUG\_ADDITIVE\_ADDITIVECONC\_REPEAT
  + Option 3 for Level 1 clustering
  + 2 cell lines \* 1 DRUG \* 1 ADDITIVE \* 4 ADDITIVE concentrations \* 4 experimental repeats (days) = 32 clusters\*
  + 2 cell lines \* 1 DRUG \* 1 ADDITIVE \* 4 ADDITIVE concentrations \* 3 experimental repeats (days) = 24 clusters\*
  + In total 56 clusters
* CELLINE\_NAME [character]
* DRUG\_NAME [character]
* ADDITIVE\_NAME [character]
* CELLINE\_DRUG\_ADDITIVE\_NAME [character]

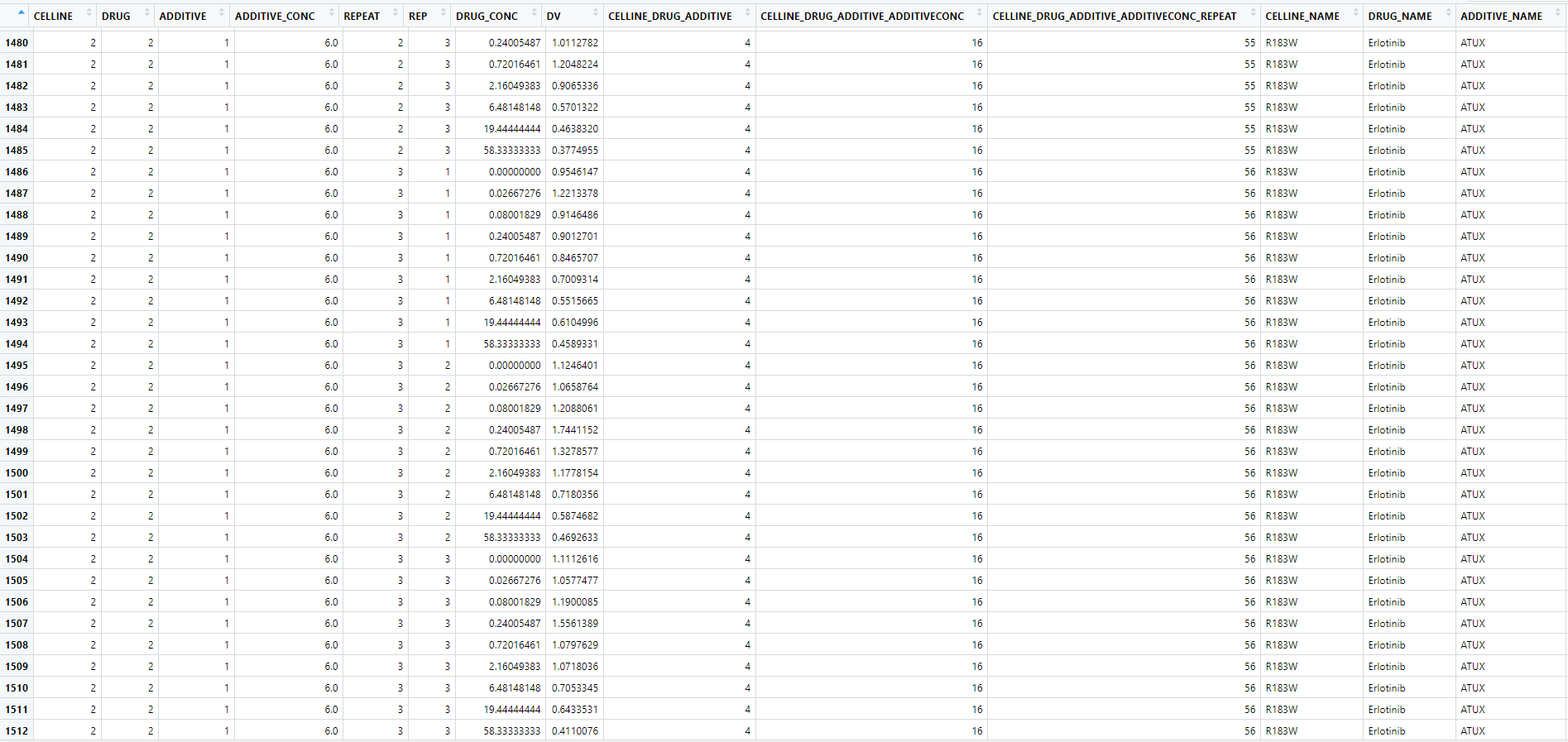
1512 data records.

Print screens of table; next pages.

Beginning of table:



End of table:



NONMEM code

;; 1. Based on: Zhigang's example

;; 2. Description: Modelling combination effect of Erlotinib and Dactolisib with ATUX

;; 3. Label: CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC as ID

;; 4. Author: My-Luong Vuong

$SIZES LTH=9999 LVR=9999

DIMCNS=9999 DIMTMP=9999 DIMNEW=9999

; DIMVRB=9999 LIM1=9999 MAXFCN=9999 NO=9999 MAXPTHETA=9999

$PROBLEM Quantitative drug sensitivity scoring of 2 coumpounds in 2 strains

$INPUT CELLINE ; 2 cell lines: WT, R183W

DRUG ; Dactolisib, Erlotinib

ADDITIVE ; ATUX

ADDITIVECONC ; 0, 3, 4.5, 6 µM

DAY ; inter-day repeats

REP ; within-day repeats

DRUGCONC ; 0.00000, 0.00076, 0.00229, 0.00686, 0.02058, 0.06173, 0.18519, 0.55556, 1.66667, 0.02667, 0.08002, 0.24005, 0.72016, 2.16049, 6.48148, 19.44444, 58.33333

DV

DROP ; ID option 1 --- CELLINE\_DRUG\_ADDITIVE

ID ; ID option 2 --- CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC ; --- Estimate parameters for each value of CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC = combination of the covariates, with REPEAT in the IOV/RUV and REP in the RUV, or ... define CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC as ID ...

DROP ; ID option 3 --- CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC\_DAY ; CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC\_REPEAT --- Estimate parameters for each value of CELLINE\_DRUG\_ADDITIVE\_ADDITIVECONC (GROUPER, previous line) = combination of the covariates, with REPEAT being the IIV and REP in the RUV

DROP ; CELLINE\_NAME

DROP ; DRUG\_NAME

DROP ; ADDITIVE\_NAME

DROP ; CELLINE\_DRUG\_ADDITIVE\_NAME

$DATA onco\_combine\_therapy.csv IGNORE=@

$PRED ;;; 2 CELL LINEs

IF(CELLINE .EQ. 1) TOP\_CELLINE = THETA(1) ;reference --- 1 FIX

IF(CELLINE .EQ. 1) BOTTOM\_CELLINE = THETA(2) ;reference --- 1 FIX

IF(CELLINE .EQ. 1) IC50\_CELLINE = THETA(3) ;reference --- 1 FIX

IF(CELLINE .EQ. 1) GAMMA\_CELLINE = THETA(4) ;reference --- 1 FIX

IF(CELLINE .EQ. 2) TOP\_CELLINE = THETA(5)

IF(CELLINE .EQ. 2) BOTTOM\_CELLINE = THETA(6)

IF(CELLINE .EQ. 2) IC50\_CELLINE = THETA(7)

IF(CELLINE .EQ. 2) GAMMA\_CELLINE = THETA(8)

;;; 2 active drugs

IF(DRUG .EQ. 1) TOP\_DRUG = THETA(9) ;reference --- 1 FIX

IF(DRUG .EQ. 1) BOTTOM\_DRUG = THETA(10) ;reference --- 1 FIX

IF(DRUG .EQ. 1) IC50\_DRUG = THETA(11) ;reference --- 1 FIX

IF(DRUG .EQ. 1) GAMMA\_DRUG = THETA(12) ;reference --- 1 FIX

IF(DRUG .EQ. 2) TOP\_DRUG = THETA(13) ;reference --- 1 FIX

IF(DRUG .EQ. 2) BOTTOM\_DRUG = THETA(14) ;reference --- 1 FIX

IF(DRUG .EQ. 2) IC50\_DRUG = THETA(15) ;reference --- 1 FIX

IF(DRUG .EQ. 2) GAMMA\_DRUG = THETA(16) ;reference --- 1 FIX

;;; ADDITIVE ATUX effect

IF(ADDITIVECONC .EQ. 0) TOP\_ADDITIVE = THETA(17) ; no ADDITIVE/HAP/SMAP is the same, can be pooled!

IF(ADDITIVECONC .EQ. 0) BOTTOM\_ADDITIVE = THETA(18) ; no ADDITIVE/HAP/SMAP is the same, can be pooled!

IF(ADDITIVECONC .EQ. 0) IC50\_ADDITIVE = THETA(19) ; no ADDITIVE/HAP/SMAP is the same, can be pooled!

IF(ADDITIVECONC .EQ. 0) GAMMA\_ADDITIVE = THETA(20) ; no ADDITIVE/HAP/SMAP is the same, can be pooled!

IF(ADDITIVECONC .EQ. 3) TOP\_ADDITIVE = THETA(21)

IF(ADDITIVECONC .EQ. 3) BOTTOM\_ADDITIVE = THETA(22)

IF(ADDITIVECONC .EQ. 3) IC50\_ADDITIVE = THETA(23)

IF(ADDITIVECONC .EQ. 3) GAMMA\_ADDITIVE = THETA(24)

IF(ADDITIVECONC .EQ. 4.5) TOP\_ADDITIVE = THETA(25)

IF(ADDITIVECONC .EQ. 4.5) BOTTOM\_ADDITIVE = THETA(26)

IF(ADDITIVECONC .EQ. 4.5) IC50\_ADDITIVE = THETA(27)

IF(ADDITIVECONC .EQ. 4.5) GAMMA\_ADDITIVE = THETA(28)

IF(ADDITIVECONC .EQ. 6) TOP\_ADDITIVE = THETA(29)

IF(ADDITIVECONC .EQ. 6) BOTTOM\_ADDITIVE = THETA(30)

IF(ADDITIVECONC .EQ. 6) IC50\_ADDITIVE = THETA(31)

IF(ADDITIVECONC .EQ. 6) GAMMA\_ADDITIVE = THETA(32)

;;; inter-day variability

DAY1=0

DAY2=0

DAY3=0

DAY4=0

IF(DAY.EQ.1) DAY1=1

IF(DAY.EQ.2) DAY2=1

IF(DAY.EQ.3) DAY3=1

IF(DAY.EQ.4) DAY4=1

TVTOP = TOP\_CELLINE \* TOP\_DRUG \* TOP\_ADDITIVE

TOP = TVTOP \* EXP(ETA(1) + DAY1 \* ETA(5) + DAY2 \* ETA(6) + DAY3 \* ETA(7) + DAY4 \* ETA(8))

TVBOTTOM = BOTTOM\_CELLINE \* BOTTOM\_DRUG \* BOTTOM\_ADDITIVE

BOTTOM = TVBOTTOM \* EXP(ETA(2) + DAY1 \* ETA(9) + DAY2 \* ETA(10) + DAY3 \* ETA(11) + DAY4 \* ETA(12))

TVIC50 = IC50\_CELLINE \* IC50\_DRUG \* IC50\_ADDITIVE

IC50 = TVIC50 \* EXP(ETA(3) + DAY1 \* ETA(13) + DAY2 \* ETA(14) + DAY3 \* ETA(15) + DAY4 \* ETA(16))

TVGAMMA = GAMMA\_CELLINE \* GAMMA\_DRUG \* GAMMA\_ADDITIVE

GAMMA = TVGAMMA \* EXP(ETA(4) + DAY1 \* ETA(17) + DAY2 \* ETA(18) + DAY3 \* ETA(19) + DAY4 \* ETA(20))

IMAX = (TOP-BOTTOM)/TOP

IPRED = BOTTOM + (TOP-BOTTOM) / (1 + (((DRUGCONC) \*\* GAMMA)/(IC50 \*\* GAMMA))) + 0.00001

W = SQRT(IPRED \*\* 2 \* SIGMA(1,1) + SIGMA(2,2))

Y = IPRED + (IPRED \* EPS(1)) + EPS(2)

IRES = DV - IPRED

IWRES = IRES / W

$THETA

(1) FIX ; reference cell line WT THETA(1)

(1) FIX ; reference cell line WT

(1) FIX ; reference cell line WT

(1) FIX ; reference cell line WT

(0, 1.01) ; THETA(5)

(0, 1.13) ;

(0, 1.11) ;

(0, 1.01) ;

(1) FIX ; reference Dactolisib THETA(9)

(1) FIX ; reference Dactolisib

(1) FIX ; reference Dactolisib

(1) FIX ; reference Dactolisib

(0, 1.04) ; THETA(13)

(0, 0.409) ;

(0, 2.26) ;

(0, 0.647) ;

(0, 0.986) ; THETA(17)

(0, 0.128) ;

(0, 1.66) ;

(0, 5.38) ;

(0, 0.945) ; THETA(21)

(0, 0.135) ;

(0, 1.5) ;

(0, 4.84) ;

(0, 0.812) ; THETA(25)

(0, 0.14) ;

(0, 1.6) ;

(0, 4.54) ;

(0, 0.508) ; THETA(29)

(0, 0.127) ;

(0, 1.91) ;

(0, 3.9) ;

$OMEGA ;;; inter-experiment variability

0 FIX

0.00427

0.0355

0.00515 ;

$OMEGA BLOCK(1) 0.00912 ; inter-day variability TOP = intra-experiment variability

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) 0.0542 ; inter-day variability BOTTOM

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) 0.0524 ; inter-day variability IC50

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) 0.0508 ; inter-day variability GAMMA

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$OMEGA BLOCK(1) SAME

$SIGMA ;;; residual variability

0.00986

0 FIX

$COVARIANCE PRINT=E UNCONDITIONAL ;MATRIX=R

$ESTIMATION METHOD=1 INTERACTION MAXEVAL=999999 POSTHOC PRINT=5 NOABORT SADDLE\_RESET=1 ;NSIG=3 SIGL=9

$TABLE ID CELLINE ADDITIVE ADDITIVECONC DRUG DAY REP DRUGCONC

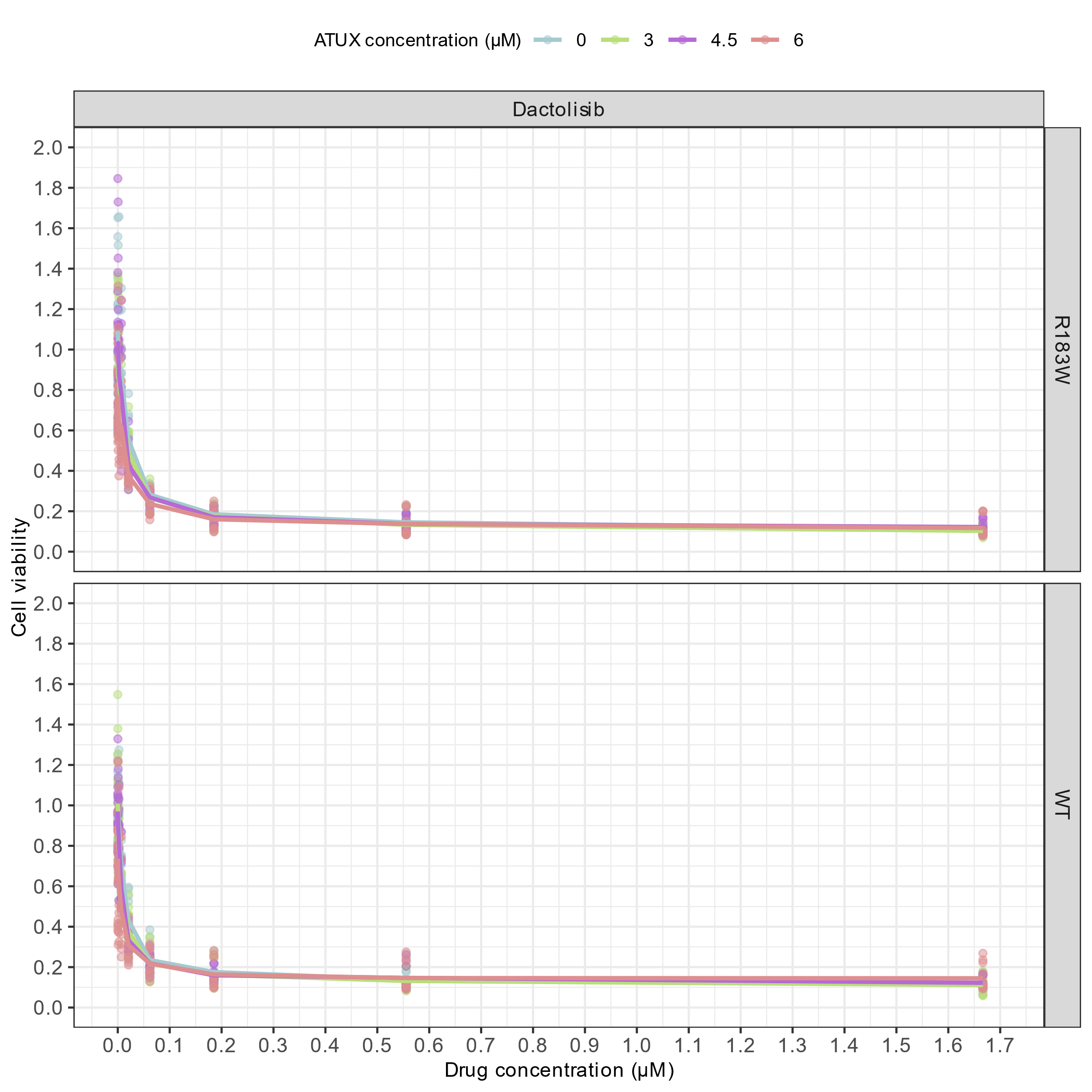
DV Y PRED IPRED IRES IWRES CWRES

TOP BOTTOM IC50 GAMMA

TVTOP TVBOTTOM TVIC50 TVGAMMA

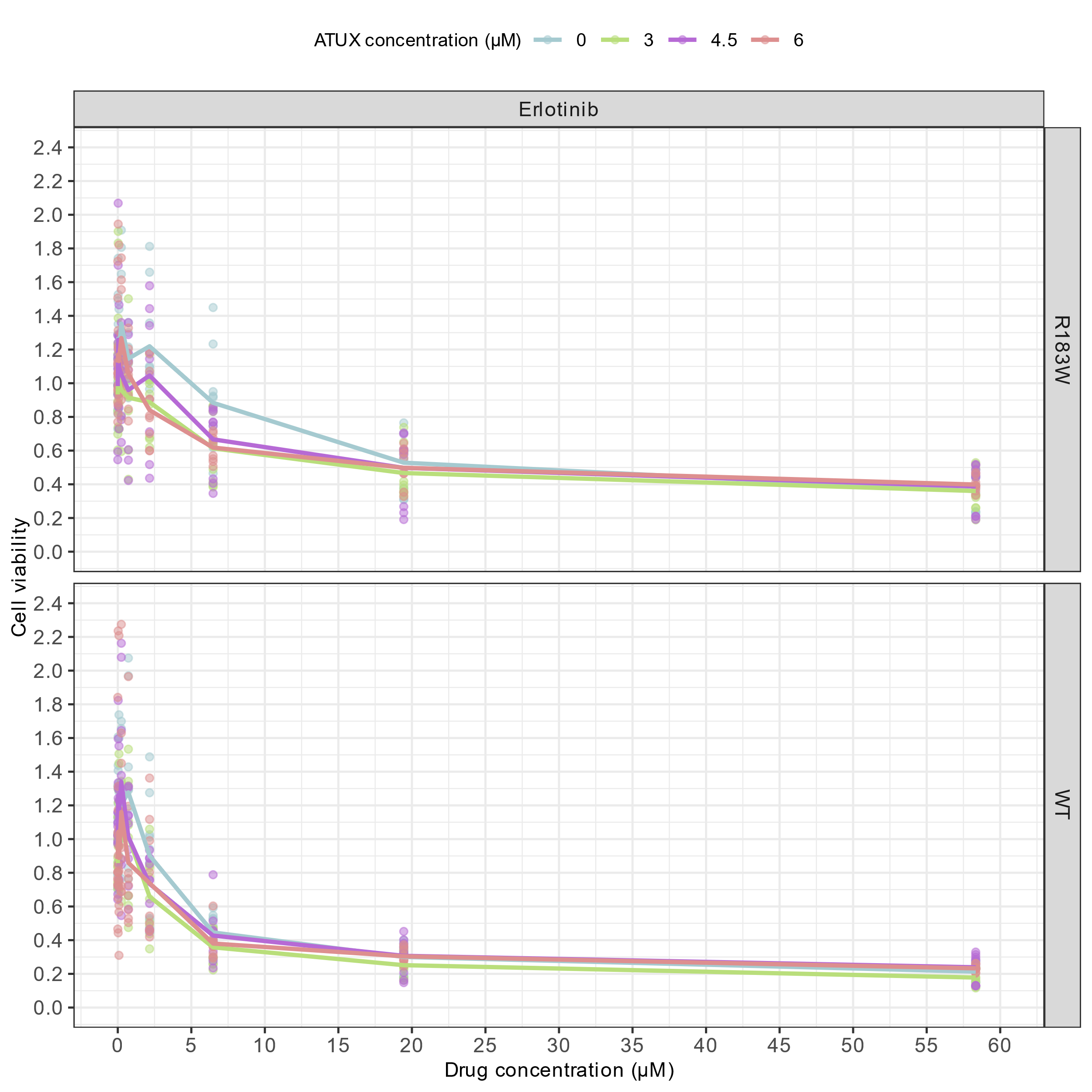
IMAX ETA(1) ETA(2) ETA(3) ETA(4)

ONEHEADER NOPRINT FILE = onco\_combine\_therapy\_out.csv



**Figure 1. Observed effect of ATUX on the response to Dactolisib in two cell lines.**

Dots represent the original data, lines indicate the median trend per ATUXconcentration.



**Figure 2. Observed effect of ATUX on the response to Erlotinib in two cell lines.**

Dots represent the original data, lines indicate the median trend per ATUXconcentration.

**Table 1. Model parameters**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **EGFP, Clofarabine** *(reference)* | **No OA** | **OA=10 nM** | **Effect of WT** | **Effect of R183W** | **Effect of R179R** | **Effect of S256F** |
| TOP (RSE) | 0.930 (3.6) | 0.623 (3.7) | ×1.16 (7.3) | ×0.990 (6.4) | ×1.04 (4.8) | ×1.17 (6.7) |
| BOTTOM (RSE) | 0.0609 (1.4) | 0.060 (1.4) | ×0.991 (1.3) | ×1.00 (1.9) | ×1.03 (2.5) | ×1.12 (2.4) |
| IC50 (µM) (RSE) | 0.214 (1.0) | 0.133 (1.4) | ×1.17 (3.2) | ×1.42 (1.8) | ×1.10 (1.1) | ×1.08 (2.4) |
| GAMMA (RSE) | 4.94 (1.3) | 5.85 (1.7) | ×0.846 (3.4) | ×0.915 (2.6) | ×0.994 (3.3) | ×0.931 (3.0) |
| *Inter-experiment variability*  *%CV (RSE) [% η-shrinkage]*  TOP  BOTTOM  IC50  GAMMA | 1.4 (20) [49, 50, 61]  0 FIX  0 FIX  0 FIX | | | | | |
| Inter-day\* variability  *%CV (RSE) [% η-shrinkage]*  TOP  BOTTOM  IC50  GAMMA | 11.6 (3.9) [0, 0, 0, 0, 35, 26, 66]  21.0 (9.2) [19, 55, 41, 49, 42, 55, 41]  15.6 (7.1) [46, 34, 36, 30, 0, 25, 62]  17.5 (9.3) [43, 26, 45, 49, 0, 38, 37] | | | | | |
| *Residual variability %CV (RSE) [% ε-shrinkage]*  Additive  Proportional | 0 FIX  7.06 (4.4) [7] | | | | | |

Model parameters are expressed as typical values (%relative standard deviation). CV: coefficient of variation. \* Inter-day/repeat variability. First-order conditional estimation with interaction was used to estimate model parameters (NONMEM version 7.5; Icon Development Solutions, Gaithersburg, Maryland, USA). The parameter estimates with 95% confidence interval including 1 are coloured in grey. RSE: relative standard error. . -2\*Ln(likelihood) = -11552.893

A picture containing plot, line

Description automatically generated

**Figure 2. Observed versus predicted cell viability plot.**  
The predicted cell viabilities consider the inter-experiment and inter-day variability. The red line is a locally weighted smoother.

A picture containing line, plot, screenshot

Description automatically generated

**Figure 3. Conditional weighted residuals (CWRES) versus predicted cell viability plot.**  
The predicted cell viabilities do not consider the inter-experiment and inter-day variability. The red line is a locally weighted smoother.

A picture containing text, line, plot, diagram

Description automatically generated

**Figure 4. Predicted AUC vs observed AUC plot.** The predicted AUC do not consider the inter-experiment and inter-day variability. The observed AUCs are calculated based on the trapezoidal rule and do not consider the inter-experiment and inter-day variability (median of repeats and replicates). The red line is a locally weighted smoother. AUC: Area under the cell viability vs compound concentration curve.

**A screenshot of a graph

Description automatically generated with low confidence**

**Figure 5. The effect of OA on the response to Clofarabine in five cell lines.**

Dots represent the original data, solid lines indicate the model fits. Dashed lines and bold asterisks indicate the IC50.

A picture containing text, screenshot, line, plot

Description automatically generated

**Figure 6. The differential drug sensitivity score (dDSS0) versus the OA concentration in five cell lines.**

The dDSS0 is calculated by subtracting the control DSS0 (OA = 0 nM) from the DSS0 (OA = 10 nM). DSS0 is calculated as .

A picture containing diagram, plan, technical drawing, schematic

Description automatically generated

**Figure 7. The differential drug sensitivity score (dDSS0) when adding OA in five cell lines.**

The dDSS0 is calculated by subtracting the control DSS0 (OA = 0 nM) from the DSS0 (OA = 10 nM). DSS0 is calculated as . The boxplots represent the interquartile range of dDSS0 from 1000 Monte Carlo simulations. The Wilcoxon test is used to examine the statistical difference in dDSS0 between cell lines. The symbols (\*\*\*\*, \*\*\*, \*\*, \*, ns) represent the significance levels of (<0.001, <0.01, <0.05, ≥0.5), respectively.