Employing **asremlPlus**, in conjunction with **asreml**, to calculate and use information criteria

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23 July, 2024

This vignette illustrates the facilities in **asremlPlus** (Brien, 2024), in conjunction with **asreml** (Butler et al., 2023), for calculating and using information. Here, **asremlPlus** and **asreml** are packages for the R Statistical Computing environment (R Core Team, 2024).

It is divided into the following main sections:

1. Set up the maximal model for this experiment
2. Obtaining information criteria for separate models
3. Obtaining information criteria for a prescribed sequence of model changes
4. Using information criteria to decide model changes

### 1. Set up the maximal model for this experiment

```r
library(knitr)
opts_chunk$set("tidy" = FALSE, comment = NA)
suppressMessages(library(asreml, quietly=TRUE))
```

```r
## Offline License checked out Tue Jul 23 20:44:33 2024

packageVersion("asreml")
```

```
## [1] ’4.2.0.332’
```

```r
suppressMessages(library(asremlPlus))
packageVersion("asremlPlus")
```

```
## [1] ’4.4.37’
```

```r
options(width = 100)
```

**Get data available in asremlPlus**

The data are from a 1976 spring wheat experiment and are taken from Gilmour et al. (1995). An analysis is presented in the **asreml** manual by Butler et al. (2023, Section 7.6), although they suggest that it is a barley experiment.
Fit the maximal model

In the following a model is fitted that has the terms that would be included for a balanced lattice. In addition, a term `WithinColPairs` has been included to allow for extraneous variation arising between pairs of adjacent lanes. Also, separable ar1 residual autocorrelation has been included. This model represents the maximal anticipated model,

```r
max.asr <- asreml(yield ~ WithinColPairs + Variety,
                   random = ~ Rep/(Row + Column) + units,
                   residual = ~ ar1(Row):ar1(Column),
                   data=Wheat.dat)
```

```
ASReml Version 4.2 23/07/2024 20:44:34
```

<table>
<thead>
<tr>
<th>LogLik</th>
<th>Sigma2</th>
<th>DF</th>
<th>wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>-724.1213</td>
<td>23034.14</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-717.4149</td>
<td>9206.931</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-694.8752</td>
<td>26492.99</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-694.1600</td>
<td>33101.80</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-692.0020</td>
<td>36912.26</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-691.7892</td>
<td>46701.51</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-691.8336</td>
<td>46208.51</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-691.7749</td>
<td>47698.26</td>
<td>124</td>
<td>20:44:34</td>
</tr>
<tr>
<td>-691.7711</td>
<td>47041.85</td>
<td>124</td>
<td>20:44:34</td>
</tr>
</tbody>
</table>

Warning in `asreml(yield ~ WithinColPairs + Variety, random = ~ Rep/(Row + Column) + units, residual = ~ ar1(Row):ar1(Column), data=Wheat.dat)`

The warning from `asreml` is probably due to a bound term.

Initialize a testing sequence by loading the current fit into an `asrtests` object

```r
max.asrt <- as.asrtests(max.asr, NULL, NULL)
```

Check for and remove any boundary terms

```r
max.asrt <- rmboundary(max.asrt)
summary(max.asrt$asreml.obj)$varcomp
```

<table>
<thead>
<tr>
<th>component</th>
<th>std.error</th>
<th>z.ratio</th>
<th>bound</th>
<th>%ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep:Row</td>
<td>4.293282e+03</td>
<td>3.199458e+03</td>
<td>1.3418779</td>
<td>P 0.0</td>
</tr>
<tr>
<td>Rep:Column</td>
<td>1.575689e+02</td>
<td>1.480357e+03</td>
<td>0.1064398</td>
<td>P 0.7</td>
</tr>
<tr>
<td>units</td>
<td>5.742689e+03</td>
<td>1.652457e+03</td>
<td>3.4752438</td>
<td>P 0.0</td>
</tr>
<tr>
<td>Row:Column!R</td>
<td>4.706787e+04</td>
<td>2.515832e+04</td>
<td>1.8708669</td>
<td>P 0.0</td>
</tr>
<tr>
<td>Row:Column!Row!cor</td>
<td>7.920301e-01</td>
<td>1.014691e-01</td>
<td>7.8056280</td>
<td>U 0.0</td>
</tr>
<tr>
<td>Row:Column!Column!cor</td>
<td>8.799559e-01</td>
<td>7.370402e-02</td>
<td>11.9390486</td>
<td>U 0.0</td>
</tr>
</tbody>
</table>
### Sequence of model investigations

(If a row has NA for \( p \) but not \( \text{denDF} \), DF and \( \text{denDF} \) relate to fixed and variance parameter numbers)

<table>
<thead>
<tr>
<th>terms</th>
<th>DF</th>
<th>denDF</th>
<th>p</th>
<th>AIC</th>
<th>BIC</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Boundary</td>
</tr>
</tbody>
</table>

Rep has been removed because it has been constrained to zero. Following the recommendation of Littell et al. (2006, p. 150), the bound on all variance components is set to unconstrained (U) using `setvariances.asreml` so as to avoid bias in the estimate of the residual variance. Alternatively, one could move Rep to the fixed model.

Unbind Rep, Row and Column components and reload into an asrtests object

```r
max.asr <- setvarianceterms(max.asr$call, 
    terms = c("Rep", "Rep:Row", "Rep:Column"), 
    bounds = "U")
```

#### Unbind Rep, Row and Column components and reload into an asrtests object

```r
max.asr <- setvarianceterms(max.asr$call, 
    terms = c("Rep", "Rep:Row", "Rep:Column"), 
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```

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```r
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```

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<table>
<thead>
<tr>
<th>LogLik</th>
<th>Sigma2</th>
<th>DF</th>
<th>wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-724.1213</td>
<td>23034.14</td>
<td>124 20:44:35 ( 2 restrained)</td>
</tr>
<tr>
<td>2</td>
<td>-717.4149</td>
<td>9206.931</td>
<td>124 20:44:35 ( 2 restrained)</td>
</tr>
<tr>
<td>3</td>
<td>-694.8752</td>
<td>26492.99</td>
<td>124 20:44:35 ( 2 restrained)</td>
</tr>
<tr>
<td>4</td>
<td>-693.9744</td>
<td>33129.65</td>
<td>124 20:44:35 ( 1 restrained)</td>
</tr>
<tr>
<td>5</td>
<td>-692.8856</td>
<td>39662.12</td>
<td>124 20:44:35</td>
</tr>
<tr>
<td>6</td>
<td>-691.4276</td>
<td>53103.83</td>
<td>124 20:44:35</td>
</tr>
<tr>
<td>7</td>
<td>-691.2387</td>
<td>48092.17</td>
<td>124 20:44:35</td>
</tr>
<tr>
<td>8</td>
<td>-691.1808</td>
<td>47278.94</td>
<td>124 20:44:35</td>
</tr>
<tr>
<td>9</td>
<td>-691.1710</td>
<td>46850.98</td>
<td>124 20:44:35</td>
</tr>
<tr>
<td>10</td>
<td>-691.1700</td>
<td>46690.46</td>
<td>124 20:44:35</td>
</tr>
</tbody>
</table>

Warning in asreml(fixed = yield ~ WithinColPairs + Variety, random = ~Rep/(Row + : Some components changed by more than 1% on the last iteration

```r
max.asr <- as.asrtests(max.asr, NULL, NULL)
max.asr <- rmboundary(max.asr)
summary(max.asr$asreml.obj)$varcomp
```

<table>
<thead>
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<th>std.error</th>
<th>z.ratio</th>
<th>bound</th>
<th>%ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep</td>
<td>-2458.3485841</td>
<td>1.197491e+03</td>
<td>-2.0529167</td>
<td>U 0.0</td>
</tr>
<tr>
<td>Rep:Row</td>
<td>5008.7151486</td>
<td>3.401335e+03</td>
<td>1.4725732</td>
<td>U 0.0</td>
</tr>
<tr>
<td>Rep:Column</td>
<td>916.4641198</td>
<td>1.699576e+03</td>
<td>0.5392309</td>
<td>U 0.2</td>
</tr>
<tr>
<td>units</td>
<td>5959.020817</td>
<td>1.609649e+03</td>
<td>3.7020634</td>
<td>P 0.0</td>
</tr>
<tr>
<td>Row:Column!R</td>
<td>46637.6303429</td>
<td>2.724392e+04</td>
<td>1.7118545</td>
<td>P 0.0</td>
</tr>
<tr>
<td>Row:Column!Row!cor</td>
<td>0.8150590</td>
<td>1.000281e-01</td>
<td>8.1483012</td>
<td>U 0.0</td>
</tr>
<tr>
<td>Row:Column!Column!cor</td>
<td>0.8856824</td>
<td>7.492514e-02</td>
<td>11.8208968</td>
<td>U 0.0</td>
</tr>
</tbody>
</table>
### Sequence of model investigations

(If a row has NA for p but not denDF, DF and denDF relate to fixed and variance parameter numbers)

[1] terms DF denDF p AIC BIC action
<0 rows> (or 0-length row.names)

Now the Rep component estimate is negative.

The `test.summary` output shows that no changes have been made to the model loaded using `as.asrtests`.
The pseudo-anova table shows that Varieties are highly significant ($p < 0.001$)

#### 2. Obtaining information criteria for separate models

The method `infoCriteria` has two methods for calculating information criteria. One, `infoCriteria.asreml`, is a method for `asreml` objects and the other, `infoCriteria.list`, if for `list` objects, the components of the `list` being `asreml` objects.

**Single models**

Firstly, `infoCriteria` is called with the default `IClikelihood`, which is `REML`. Then it is called with `IClikelihood` set to `full` (Verbyla, 2019).

```
infoCriteria(max.asr)
```

+ fixedDF varDF NBound | AIC | BIC | loglik
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>7</td>
<td>1396.34</td>
</tr>
</tbody>
</table>

```
infoCriteria(max.asr, IClikelihood = "full")
```

```
ASReml Version 4.2 23/07/2024 20:44:36
LogLik Sigma2 DF wall
1  -691.1700 46627.05 124 20:44:36

Warning in asreml(fixed = yield ~ WithinColPairs + Variety, random = ~Rep/(Row + : Log-likelihood not converged)

+ fixedDF varDF NBound | AIC | BIC | loglik
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>7</td>
<td>1647.191</td>
</tr>
</tbody>
</table>
```
A list of models

Now, a second model, from which the `withinColPairs` term has been omitted, is fitted; to be consistent, the variance components are unconstrained using `setvariances.asreml`. Then the `asreml` objects for this model and the maximal model are combined into a list and a `data.frame` produced that includes their information criteria.

```r
m1.asr <- asreml(yield ~ Variety,
                   random = ~ Rep/(Row + Column) + units,
                   residual = ~ ar1(Row):ar1(Column),
                   data=Wheat.dat)

ASReml Version 4.2 23/07/2024 20:44:36
LogLik   Sigma2    DF   wall
1 -727.7742  22898.99  125 20:44:36
2 -721.0966  9190.303  125 20:44:36 ( 2 restrained)
3 -698.3135  26671.76  125 20:44:36 ( 2 restrained)
4 -697.5170  32677.28  125 20:44:36 ( 1 restrained)
5 -695.4192  36662.76  125 20:44:36 ( 1 restrained)
6 -695.2077  46263.96  125 20:44:36 ( 2 restrained)
7 -695.1975  46156.63  125 20:44:36
8 -695.1906  46630.21  125 20:44:36

Warning in asreml(yield ~ Variety, random = ~Rep/(Row + Column) + units, : Some components changed by more than 1% on the last iteration

m1.asr <- setvariances(m1.asr$call,
                       terms = c("Rep", "Rep:Row", "Rep:Column"),
                       bounds = "U")

ASReml Version 4.2 23/07/2024 20:44:36
LogLik   Sigma2    DF   wall
1 -727.7742  22898.99  125 20:44:36
2 -721.0966  9190.303  125 20:44:36 ( 2 restrained)
3 -698.3135  26671.76  125 20:44:36 ( 2 restrained)
4 -697.3331  32689.33  125 20:44:36 ( 1 restrained)
5 -697.0164  39975.97  125 20:44:36
6 -695.0695  54825.30  125 20:44:36
7 -695.1975  46156.63  125 20:44:36
8 -695.1906  46630.21  125 20:44:36
9 -694.7571  47637.20  125 20:44:36
10 -694.6436  46775.41  125 20:44:36
11 -694.6181  45940.69  125 20:44:36
12 -694.6152  45940.69  125 20:44:36

Warning in asreml(fixed = yield ~ Variety, random = ~Rep/(Row + Column) + : Some components changed by more than 1% on the last iteration

mods <- list(max = max.asr, m1 = m1.asr)
ic <- infoCriteria(mods, IClikelihood = "full")
print(ic)

fixedDF varDF NBound   AIC   BIC   loglik
max   26   7     0 1647.191 1746.542 -790.5957
m1    25   7     0 1645.318 1741.658 -790.6588
3. Obtaining information criteria for a prescribed sequence of model changes

The use of `changeTerms.asrtests` is demonstrated for a sequence of models, starting with the maximal model.

**Drop the term for within Column pairs (a post hoc factor)**

```r
current.asrt <- as.asrtests(max.asrt$asreml.obj, NULL, NULL,
                           label = "Maximal model", IClikelihood = "full")
```

```
Warning in asreml(fixed = yield ~ WithinColPairs + Variety, random = ~Rep/(Row + : Log-likelihood not converged

current.asrt <- changeTerms(current.asrt,
                           dropFixed = "WithinColPairs",
                           label = "Drop withinColPairs", IClikelihood = "full")
```

```
Warning in asreml(fixed = yield ~ Variety, random = ~Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration

Warning in asreml(fixed = yield ~ Variety, random = ~Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration

print(current.asrt, which = "testsummary", omit.columns = "p")
```

```r
### Sequence of model investigations

(If a row has NA for p but not denDF, DF and denDF relate to fixed and variance parameter numbers)

<table>
<thead>
<tr>
<th>terms</th>
<th>DF</th>
<th>denDF</th>
<th>AIC</th>
<th>BIC</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal model</td>
<td>26</td>
<td>7</td>
<td>1647.191</td>
<td>1746.542</td>
<td>Starting model</td>
</tr>
<tr>
<td>Drop withinColPairs</td>
<td>25</td>
<td>7</td>
<td>1645.325</td>
<td>1741.666</td>
<td>Changed fixed</td>
</tr>
</tbody>
</table>

So the same values of the information criteria have been obtained as when `infoCriteria.list` was used on a list containing the `asreml` objects for the two models. The differences is that here there is ultimately only one fitted model, the model stored in the `asreml` object in the `asrtests` object named `current.asrt`: this is the model with `withinColPairs` omitted.

Note this use of the `omit.columns` argument from `print.test.summary` to omit the irrelevant column `p` from the `test.summary`.

**Drop nugget term**

```r
current.asrt <- changeTerms(current.asrt, dropRandom = "units",
                            label = "Drop units", IClikelihood = "full")
```
Warning in asreml(fixed = yield ~ Variety, random = ~Rep + Rep:Row + Rep:Column, : Some components changed by more than 1% on the last iteration
Warning in asreml(fixed = yield ~ Variety, random = ~Rep + Rep:Row + Rep:Column, : Some components changed by more than 1% on the last iteration

Check Row autocorrelation

```r
current.asrt <- changeTerms(current.asrt, newResidual = "Row:ar1(Column)",
                         label = "Row autocorrelation", IClikelihood = "full")
print(current.asrt, which = "testsummary", omit.columns = "p")
```

### Sequence of model investigations

(If a row has NA for p but not denDF, DF and denDF relate to fixed and variance parameter numbers)

<table>
<thead>
<tr>
<th>terms</th>
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<tr>
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<td>7</td>
<td>1647.191</td>
<td>1746.542</td>
<td>Starting model</td>
</tr>
<tr>
<td>Drop withinColPairs</td>
<td>25</td>
<td>7</td>
<td>1645.325</td>
<td>1741.666</td>
<td>Changed fixed</td>
</tr>
<tr>
<td>Drop units</td>
<td>25</td>
<td>6</td>
<td>1650.126</td>
<td>1743.456</td>
<td>Changed random</td>
</tr>
<tr>
<td>Row autocorrelation</td>
<td>25</td>
<td>5</td>
<td>1660.882</td>
<td>1751.201</td>
<td>Changed residual</td>
</tr>
</tbody>
</table>

4. Using information criteria to decide model changes

This sections illustrates the use of `changeModelOnIC.asrtests` to decide between consecutive models in a sequence of models. The default information criterion to use for this is the AIC. However, `which.IC` can be used to specify the use of the BIC or both. Here we use the AIC and the full likelihood.

Check the term for within Column pairs (a post hoc factor)

As before, we start with the maximal model, in which the variance components have been unconstrained and look to decide whether of not to drop the `withinColPairs` term.

```r
current.asrt <- as.asrtests(max.asrt$asreml.obj, NULL, NULL,
                         label = "Maximal model", IClikelihood = "full")
```

Warning in asreml(fixed = yield ~ WithinColPairs + Variety, random = ~Rep/(Row + : Log-likelihood not converged

```r
current.asrt <- iterate(current.asrt)
current.asrt <- changeModelOnIC(current.asrt, dropFixed = "WithinColPairs",
                         label = "withinColPairs",
                         IClikelihood = "full", which.IC = "AIC",
                         allow.unconverged = FALSE)
```

Warning in asreml(fixed = yield ~ Variety, random = ~Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration
Warning in asreml(fixed = yield ~ Variety, random = -Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration

\texttt{print(current.asrt, which = "testsummary", omit.columns = "p")}

### Sequence of model investigations

(If a row has NA for p but not denDF, DF and denDF relate to fixed and variance parameter numbers)

<table>
<thead>
<tr>
<th>terms</th>
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<th>denDF</th>
<th>AIC</th>
<th>BIC</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal model</td>
<td>26</td>
<td>7</td>
<td>1647.191452</td>
<td>1746.542417</td>
<td>Starting model</td>
</tr>
<tr>
<td>withinColPairs</td>
<td>-1</td>
<td>0</td>
<td>-1.866103</td>
<td>-4.876738</td>
<td>Swapped</td>
</tr>
</tbody>
</table>

Given the warning about a lack of convergence, we use \texttt{iterate.asrtests} to perform additional iterations of the fitting process. It seems that it was successful.

It can be seen from the \texttt{test.summary} that the term has been swapped out and this has the effect of reducing the number of fixed parameters by one and makes no change to the variance parameters.

Check the nugget term

\texttt{current.asrt <- changeModelOnIC(current.asrt, dropRandom = "units", label = "units", IClikelihood = "full", allow.unconverged = FALSE)}

Warning in asreml(fixed = yield ~ Variety, random = -Rep + Rep:Row + Rep:Column, : Some components changed by more than 1% on the last iteration

Check Row autocorrelation

\texttt{current.asrt <- changeModelOnIC(current.asrt, newResidual = "Row:ar1(Column)", label="Row autocorrelation", IClikelihood = "full", allow.unconverged = FALSE)}

Warning in asreml(fixed = yield ~ Variety, random = -Rep + units + Rep:Row + : Log-likelihood not converged

Warning in asreml(fixed = yield ~ Variety, random = -Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration

Warning in asreml(fixed = yield ~ Variety, random = -Rep + units + Rep:Row + : Log-likelihood not converged

Warning in asreml(fixed = yield ~ Variety, random = -Rep + units + Rep:Row + : Some components changed by more than 1% on the last iteration

Warning in newfit.asreml(asreml.obj, fixed. = fix.form, random. = ran.form, :
Check Column autocorrelation (depends on whether Row autocorrelation retained)

```
{  
  last.action <- current.asrt$test.summary$action[current.asrt$test.summary$terms ==
          "Row autocorrelation"]

  if (grepl("Unswapped", last.action, fixed = TRUE) |
      grepl("Unchanged", last.action, fixed = TRUE))
    current.asrt <- changeModelOnIC(current.asrt, 
          newResidual = "ar1(Row):Column", 
          label="Col autocorrelation", IClikelihood = "full", 
          allow.unconverged = FALSE)
  else 
    current.asrt <- testresidual(current.asrt, 
          newResidual = "Row:Column", 
          label="Col autocorrelation", IClikelihood = "full", 
          allow.unconverged = FALSE)
}
```

Warning in infoCriteria.asreml(asreml.obj, IClikelihood = ic.lik, bound.exclusions = bound.exclusions):
Row:Column!Row!cor

Warning in rmboundary.asrtests(as.asrtests(asreml.obj, wald.tab, test.summary, : In analysing yield, est
Row:Column!Row!cor

Warning in infoCriteria.asreml(new.asrtests.obj$asreml.obj, IClikelihood = ic.lik, : The following bound
Row:Column!Row!cor

Output the results

```
print(current.asrt, which = "test", omit.columns = "p")
```

#### Sequence of model investigations

(If a row has NA for p but not denDF, DF and denDF relate to fixed and variance parameter numbers)

<table>
<thead>
<tr>
<th>terms</th>
<th>DF</th>
<th>denDF</th>
<th>AIC</th>
<th>BIC</th>
<th>action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal model</td>
<td>26</td>
<td>7</td>
<td>1.647191e+03</td>
<td>1.746542e+03</td>
<td>Starting model</td>
</tr>
<tr>
<td>withinColPairs</td>
<td>-1</td>
<td>0</td>
<td>-1.866103e+00</td>
<td>-4.876738e+00</td>
<td>Swapped</td>
</tr>
<tr>
<td>units</td>
<td>0</td>
<td>-1</td>
<td>4.801053e+00</td>
<td>1.790418e+00</td>
<td>Unswapped</td>
</tr>
<tr>
<td>Row autocorrelation</td>
<td>0</td>
<td>0</td>
<td>-7.342295e-03</td>
<td>-7.342295e-03</td>
<td>Unchanged - new unconverged</td>
</tr>
<tr>
<td>Col autocorrelation</td>
<td>0</td>
<td>-2</td>
<td>1.947985e+01</td>
<td>1.345858e+01</td>
<td>Unswapped</td>
</tr>
</tbody>
</table>

```
summary(current.asrt$asreml.obj)$varcomp
```

<table>
<thead>
<tr>
<th>component</th>
<th>std.error</th>
<th>z.ratio</th>
<th>bound</th>
<th>%ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep</td>
<td>-2391.894799</td>
<td>1.194671e+03</td>
<td>-2.002136</td>
<td>U 0.4</td>
</tr>
<tr>
<td>Rep:Row</td>
<td>5035.4828349</td>
<td>3.406065e+03</td>
<td>1.478387</td>
<td>U 0.3</td>
</tr>
</tbody>
</table>
The test.summary shows us that the model without the autocorrelation failed to converge and so no change was made to the model. It, and the messages from checking the Column autocorrelation, also show us that the omission of the Column autocorrelation resulted in the Row autocorrelation becoming bound. That is, dropping the Column autocorrelation resulted in the dropping of two variance parameters.

The function printFormulae.asreml is used to display the fitted model.

```r
printFormulae(current.asr$asreml.obj)
```

### Formulae from asreml object

fixed: yield ~ Variety
random: ~ Rep + units + Rep:Row + Rep:Column
residual: ~ ar1(Row):ar1(Column)

References


