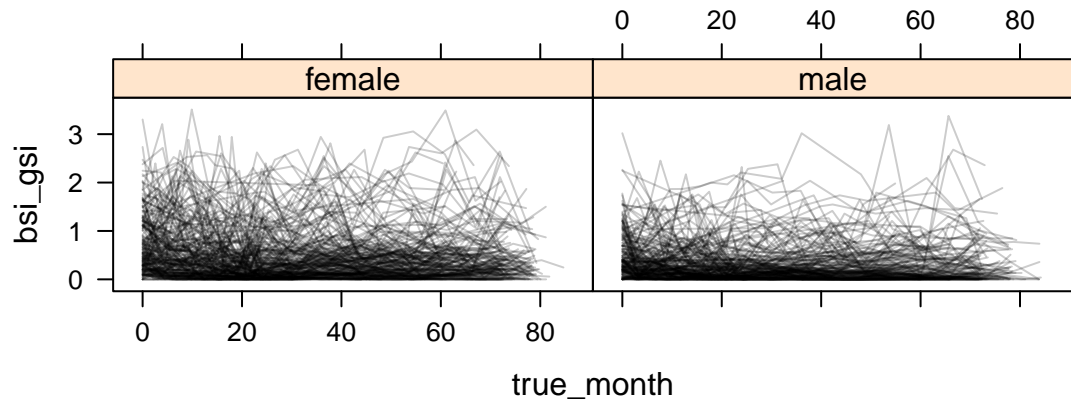


BSI data: step function and bent line

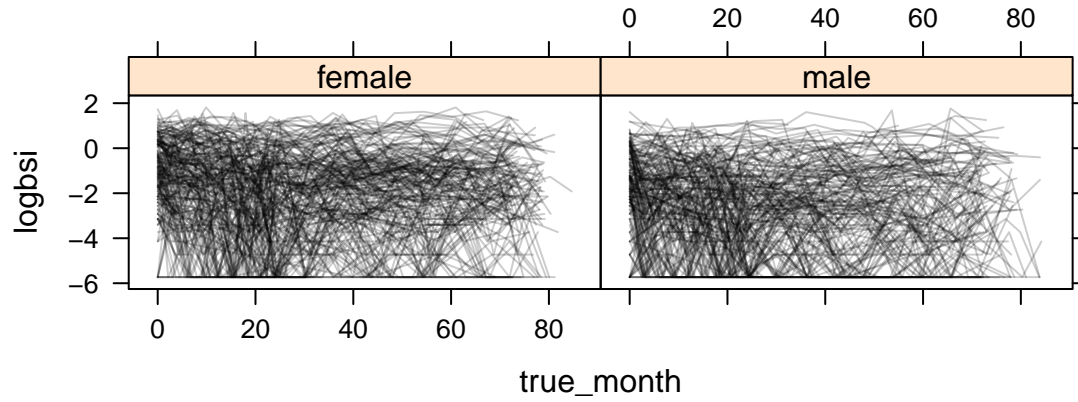
```
> bsi.all <- read.delim("http://rem.ph.ucla.edu/rob/mld/data/tabdelimiteddata/bsitotal.txt")
> bsi <- subset(bsi.all, select = c("pid", "parent", "gender",
+   "true_month", "rounded3_true_month", "season", "bsi_gsi"))
> bsi$parent <- factor(bsi$parent)
> bsi$pid <- factor(bsi$pid)
> head(bsi)
```

	pid	parent	gender	true_month	rounded3_true_month	season	bsi_gsi
1	11	10	male	0.000000	0	winter (11,12,1,2)	0.3018868
2	11	10	male	9.921971	9	winter (11,12,1,2)	0.3962264
3	11	10	male	26.743326	27	spring (3-6)	0.3962264
4	11	10	male	36.336756	36	winter (11,12,1,2)	0.0000000
5	11	10	male	40.673511	42	spring (3-6)	0.5660377
6	11	10	male	44.024641	45	summer (7-10)	0.5094340

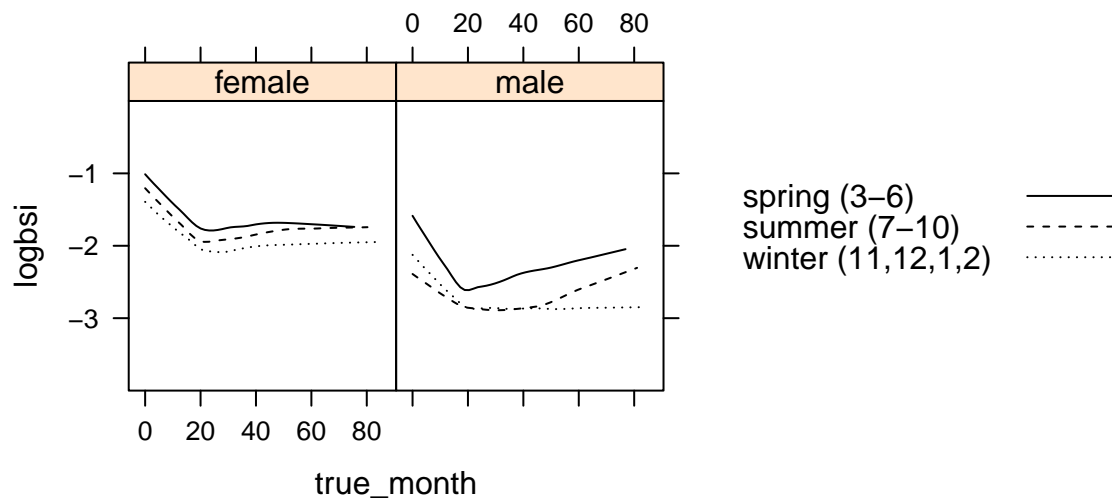
```
> plot(xyplot(bsi_gsi ~ true_month | gender, group = pid, type = c("l"),
+   data = bsi, par.settings = black, alpha = 0.2))
```



```
> bsi$logbsi <- log2(bsi$bsi_gsi + 1/53)
> plot(xyplot(logbsi ~ true_month | gender, group = pid, type = c("l"),
+   data = bsi, par.settings = black, alpha = 0.2))
```



```
> black2 <- black
> black2$superpose.line$lty <- 1:3
> plot(xyplot(logbsi ~ true_month | gender, group = season, type = c("smooth"),
+   ylim = c(-4, 0), data = bsi, par.settings = black2, auto.key = list(space = "right",
+   points = FALSE, lines = TRUE)))
```



Bent-line models...

A bent-line model

See section 7.6.7, page 225–226.

We fit a bent-line model to the data with knots at 18 months and 36 months, and a step function for season, and an additive effect for gender. Whew!

```
> bsi$month3 <- bsi$rounded3_true_month/3
> bsi$knot18 <- (bsi$true_month - 18) * (bsi$true_month >= 18)
> bsi$knot36 <- (bsi$true_month - 36) * (bsi$true_month >= 36)

> m1 <- lme(logbsi ~ gender + season + true_month + knot18 + knot36,
+          random = ~1 | parent, correlation = corARMA(form = ~month3 |
+              parent/pid, p = 1, q = 1), data = bsi)
> summary(m1)

...
Random effects:
  Formula: ~1 | parent
          (Intercept) Residual
StdDev:    0.6739568  1.818258

Correlation Structure: ARMA(1,1)
  Formula: ~month3 | parent/pid
Parameter estimate(s):
      Phi1      Theta1
0.9516388 -0.6717504
Fixed effects: logbsi ~ gender + season + true_month + knot18 + knot36
              Value Std.Error   DF   t-value p-value
(Intercept)   -1.0434520 0.11497223 4571  -9.075687  0.0000
gendermale     -0.6524386 0.13370556 4571  -4.879667  0.0000
seasonsummer (7-10) -0.1741913 0.04481672 4571  -3.886748  0.0001
seasonwinter (11,12,1,2) -0.1607538 0.04415052 4571  -3.641040  0.0003
true_month     -0.0623818 0.00480966 4571 -12.970096  0.0000
knot18         0.0805571 0.00817386 4571   9.855458  0.0000
knot36        -0.0201480 0.00658912 4571  -3.057773  0.0022
...

```

The slopes

```
> K1
```

```
      [,1] [,2] [,3] [,4] [,5] [,6] [,7]
slope before 18    0    0    0    0    1    0    0
slope 18 to 36    0    0    0    0    1    1    0
slope after 36    0    0    0    0    1    1    1
```

```
> t1 <- glht(m1, linfct = K1)
> summary(t1, test = adjusted(type = "none"))
```

Simultaneous Tests for General Linear Hypotheses

```
Fit: lme.formula(fixed = logbsi ~ gender + season + true_month + knot18 +
  knot36, data = bsi, random = ~1 | parent, correlation = corARMA(form = ~month3 |
  parent/pid, p = 1, q = 1))
```

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(> z)
slope before 18 == 0	-0.062382	0.004810	-12.970	< 2e-16
slope 18 to 36 == 0	0.018175	0.004849	3.748	0.000178
slope after 36 == 0	-0.001973	0.002899	-0.680	0.496203

(Adjusted p values reported -- none method)

```
> K2
```

```
      [,1] [,2] [,3] [,4] [,5] [,6] [,7]
spring-summer    0    0   -1    0    0    0    0
spring-winter    0    0    0   -1    0    0    0
winter-summer    0    0   -1    1    0    0    0
```

```
> t2 <- glht(m1, linfct = K2)
> summary(t2)
```

Simultaneous Tests for General Linear Hypotheses

```
Fit: lme.formula(fixed = logbsi ~ gender + season + true_month + knot18 +
  knot36, data = bsi, random = ~1 | parent, correlation = corARMA(form = ~month3 |
  parent/pid, p = 1, q = 1))
```

Linear Hypotheses:

	Estimate	Std. Error	z value	Pr(> z)
spring-summer == 0	0.17419	0.04482	3.887	0.000294
spring-winter == 0	0.16075	0.04415	3.641	0.000782
winter-summer == 0	0.01344	0.04498	0.299	0.951998

(Adjusted p values reported -- single-step method)

What's the percent increase from summer to spring?

This SAS code supposedly does the same thing. Did it really? Compare the fitted coefficients.

SAS input

```
data bsi;
  set bsitotal;
  knot18 = (true_month - 18)*(true_month >= 18);
  knot36 = (true_month - 36)*(true_month >= 36);
  spring = (season = "spring (3-6)");
  summer = (season = "summer (7-10)");
  l2bsi_gsi = log2(bsi_gsi + 1/53);
run;

proc mixed data=bsi noclprint noitprint covtest method = reml;
  class pid parent rounded3_true_month gender ;
  model l2bsi_gsi = true_month knot18 knot36 spring summer gender / solution notest;
  repeated rounded3_true_month /subject=pid(parent) type=arma(1,1);
  random intercept / subject=parent;
  estimate 'slope before 18' true_month 1;
  estimate 'slope 18-36' true_month 1 knot18 1;
  estimate 'slope after 36' true_month 1 knot18 1 knot36 1;
  estimate 'spring - summer' spring 1 summer -1;
run ;
```

SAS output

...

Solution for Fixed Effects						
Effect	gender	Estimate	Standard Error	DF	t Value	Pr > t
Intercept		-1.8566	0.1204	279	-15.42	<.0001
true_month		-0.06238	0.004810	4571	-12.97	<.0001
knot18		0.08056	0.008174	4571	9.86	<.0001
knot36		-0.02015	0.006589	4571	-3.06	0.0022
spring		0.1608	0.04415	4571	3.64	0.0003
summer		-0.01344	0.04498	4571	-0.30	0.7652
gender	female	0.6524	0.1337	4571	4.88	<.0001
gender	male	0

Estimates					
Label	Estimate	Standard Error	DF	t Value	Pr > t
slope before 18	-0.06238	0.004810	4571	-12.97	<.0001
slope 18-36	0.01818	0.004849	4571	3.75	0.0002
slope after 36	-0.00197	0.002899	4571	-0.68	0.4962
spring - summer	0.1742	0.04482	4571	3.89	0.0001

A more complex model

```
> m1b <- update(m1, method = "ML")
> m2b <- lme(logbsi ~ season * gender * (true_month + knot18 +
+   knot36), random = ~1 | parent, correlation = corARMA(form = ~month3 |
+   parent/pid, p = 1, q = 1), data = bsi, method = "ML")
> summary(m2b)
```

...

Random effects:

Formula: ~1 | parent

(Intercept) Residual

StdDev: 0.6787962 1.812946

Correlation Structure: ARMA(1,1)

Formula: ~month3 | parent/pid

Parameter estimate(s):

Phi1 Theta1

0.9518882 -0.6715515

Fixed effects: logbsi ~ season * gender * (true_month + knot18 + knot36)

	Value	Std.Error	DF
(Intercept)	-1.0287666	0.14950295	4554
seasonsummer (7-10)	-0.0199136	0.16213915	4554
seasonwinter (11,12,1,2)	-0.1324293	0.16664859	4554
gendermale	-0.6190445	0.21229964	4554
true_month	-0.0597249	0.00992662	4554
knot18	0.0775211	0.01738792	4554
knot36	-0.0252404	0.01359686	4554
seasonsummer (7-10):gendermale	-0.7686966	0.23549551	4554
seasonwinter (11,12,1,2):gendermale	0.2028771	0.24359335	4554
seasonsummer (7-10):true_month	-0.0176711	0.01366704	4554
seasonwinter (11,12,1,2):true_month	-0.0136611	0.01400690	4554
seasonsummer (7-10):knot18	0.0264393	0.02353075	4554
seasonwinter (11,12,1,2):knot18	0.0272826	0.02383437	4554
seasonsummer (7-10):knot36	-0.0043876	0.01767732	4554
seasonwinter (11,12,1,2):knot36	-0.0128427	0.01740960	4554
gendermale:true_month	-0.0089065	0.01433895	4554
gendermale:knot18	0.0080564	0.02518033	4554
gendermale:knot36	0.0127225	0.02030658	4554
seasonsummer (7-10):gendermale:true_month	0.0705207	0.01965210	4554
seasonwinter (11,12,1,2):gendermale:true_month	0.0045905	0.02023006	4554
seasonsummer (7-10):gendermale:knot18	-0.0994695	0.03386764	4554
seasonwinter (11,12,1,2):gendermale:knot18	-0.0189266	0.03449034	4554
seasonsummer (7-10):gendermale:knot36	0.0267593	0.02623420	4554
seasonwinter (11,12,1,2):gendermale:knot36	0.0078450	0.02593049	4554
	t-value	p-value	
(Intercept)	-6.881246	0.0000	
seasonsummer (7-10)	-0.122818	0.9023	

```

seasonwinter (11,12,1,2)          -0.794662  0.4269
gendermale                       -2.915900  0.0036
true_month                       -6.016640  0.0000
knot18                            4.458333  0.0000
knot36                           -1.856340  0.0635
seasonsummer (7-10):gendermale   -3.264167  0.0011
seasonwinter (11,12,1,2):gendermale  0.832851  0.4050
seasonsummer (7-10):true_month   -1.292975  0.1961
seasonwinter (11,12,1,2):true_month -0.975311  0.3295
seasonsummer (7-10):knot18       1.123605  0.2612
seasonwinter (11,12,1,2):knot18   1.144676  0.2524
seasonsummer (7-10):knot36       -0.248205  0.8040
seasonwinter (11,12,1,2):knot36  -0.737682  0.4607
gendermale:true_month            -0.621140  0.5345
gendermale:knot18                0.319949  0.7490
gendermale:knot36                0.626520  0.5310
seasonsummer (7-10):gendermale:true_month  3.588454  0.0003
seasonwinter (11,12,1,2):gendermale:true_month  0.226914  0.8205
seasonsummer (7-10):gendermale:knot18  -2.937008  0.0033
seasonwinter (11,12,1,2):gendermale:knot18 -0.548751  0.5832
seasonsummer (7-10):gendermale:knot36   1.020015  0.3078
seasonwinter (11,12,1,2):gendermale:knot36  0.302540  0.7623
...

```

```
> anova(m1b, m2b)
```

	Model	df	AIC	BIC	logLik	Test	L.Ratio	p-value
m1b	1	11	17530.58	17601.95	-8754.288			
m2b	2	28	17529.46	17711.13	-8736.731	1 vs 2	35.11316	0.006