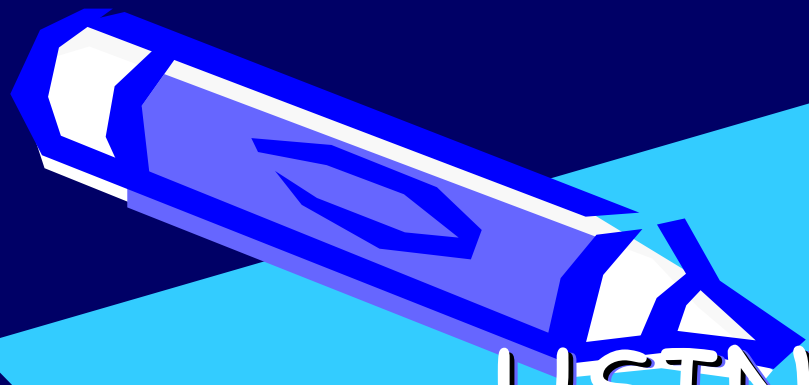
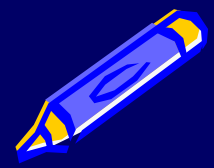
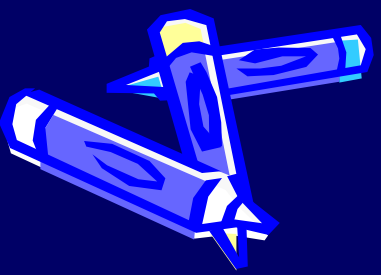


USING SAS IN NONLINEAR-MIXED MODELS

Lin Ju
(co-op student)
Ministry of Forests



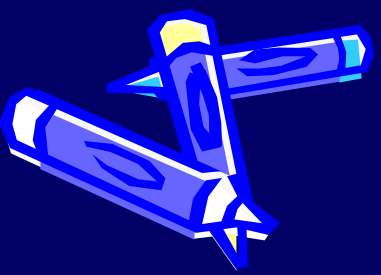
- Mixed model
- Proc Nlmixed
  - Basic algorithm
  - Tips in model fitting
- Results



Mixed Model

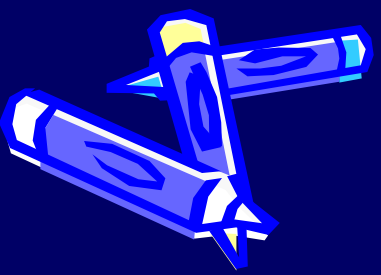
- Mixed model

  $y_i \sim f(x_i) + r_i + e_i$
- Nonlinear mixed model
- Why nonlinear mixed model



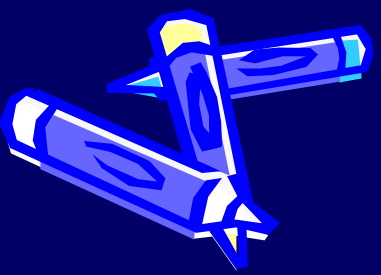
Nonlinear Mixed Model

- Proc Nlmixed
- %NLINMIX macro



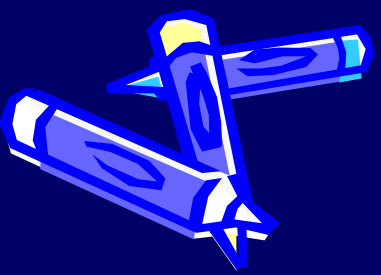
Proc Nlmixed----Basic Algorithm

- Maximizing the approximation to the likelihood integrated over random effects
- First-order taylor series approximation
- Adaptive Gaussian quadrate approximation



Proc Nlmixed---Syntax

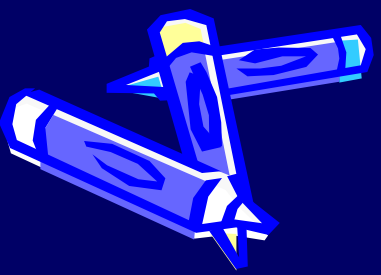
- **proc nlmixed** data=both2 tech=trureg ;
- parms b=**3** amn=**20** avar=**10** s2e=10 ;
- y =a*(x**b);
- delta=y-fitted;
- model delta~normal(**0**,s2e);
- random a~ normal (amn, avar) subject=tree;



Proc Nlmixed--Output

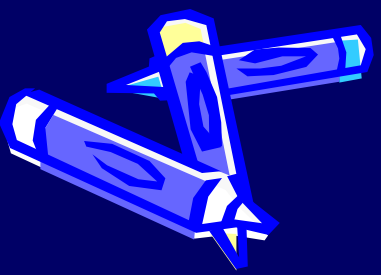
- Parameter estimates (mean, standard error, DF, t value, Pr>t, alpha, low, upper, gradient)

- Fit information (-2loglikelihood, AIC, BIC)



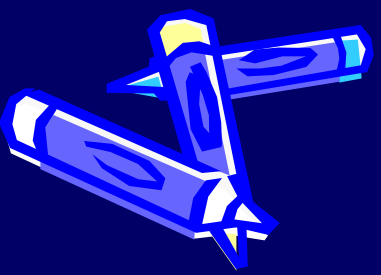
Proc Nlmixed---Convergence

- Small gradients for every parameters(less than 1E-3)
- A positive definite Hessian Matrix
- Small overall value for convergence criteria



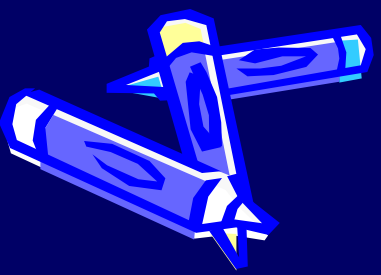
Proc Nlmixed—Troubleshooting

- Rescale parameters
- Independent parameters
- Boundary constrains
- Starting values for parameters



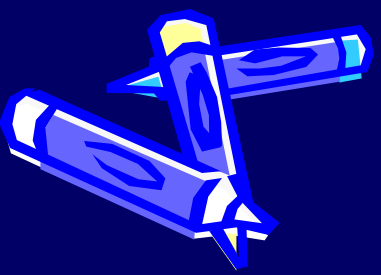
Proc Nlmixed---Initial value guess for parameters

- Fit a model without random effects (reduced model)
- Fit a reduced model by Proc Nlin
- Use the output from previous ones to determine good start values
- Return the model by using the optimum value



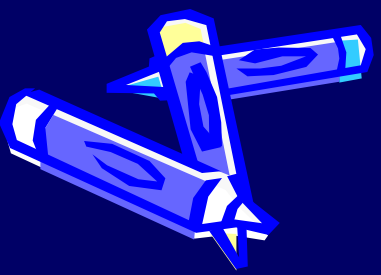
Proc Nlmixed---
Other Tips

- Add Put statement to output critical variables
- Place check and bounds to prevent outflows and underflows
- Specify the ITDETAILS option



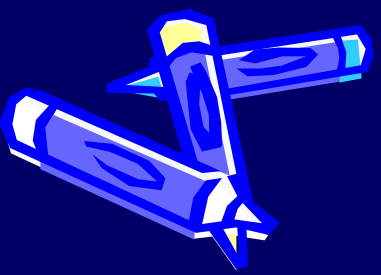
Proc Nlmixed ---3 random effects

- Condition and properties of covariance matrix
- Parameterize the covariance matrix in terms of variances and correlations
- Place bounds on the correlation parameter



Proc Nlmixed---3 random effects

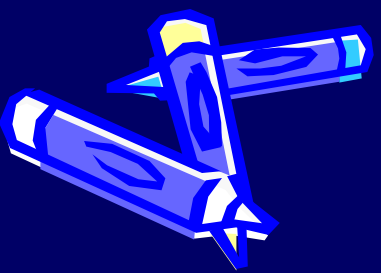
- bounds -1<rho<1, -1<rho1<1, -1<rho2<1;
- covab=sqrt(avar*bvar)*rho;
- covac=sqrt(avar*cvar)*rho1;
- covbc=sqrt(bvar*cvar)*rho2;



Proc Nlmixed—3 random effects

- **proc nlmixed** data=raw2 tech=trureg ;
  parms amn=1.82 avar=0.01 bmn=1.23 bvar=0.01 cmn=1.19 cvar=0.01 s2e=0.07 d=0.93 rho=0 rho1=0 rho2=0;

- random a b c ~normal([amn,bmn,cmn],[avar,covab,bvar,covac,covbc,cvar]) subject=tree;

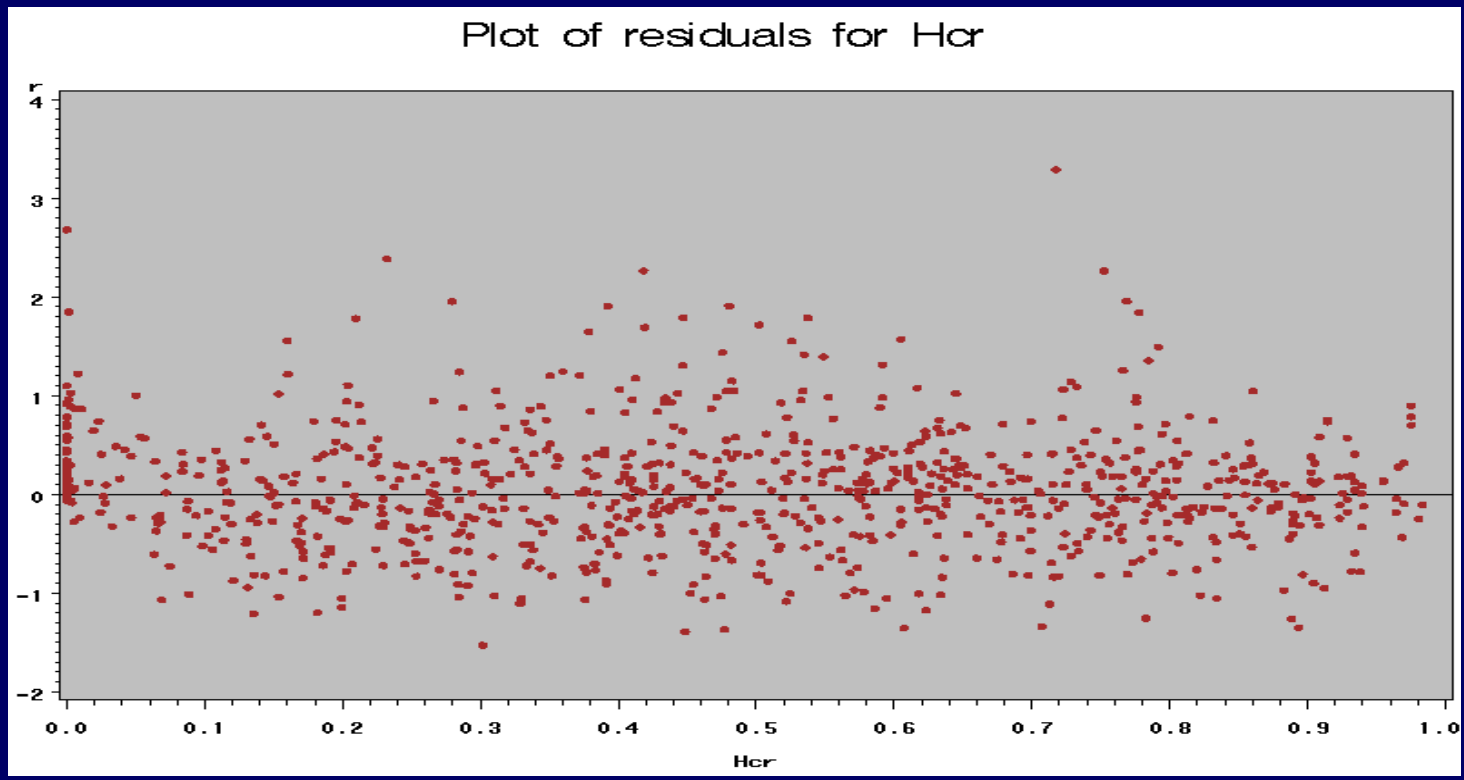


Results--I

- Total foliar biomass (a is random effect)

$$B_F = a \cdot D^{b_1} \cdot H_{CR}^{b_2} \cdot e^{A \cdot b_3}$$

Results---I

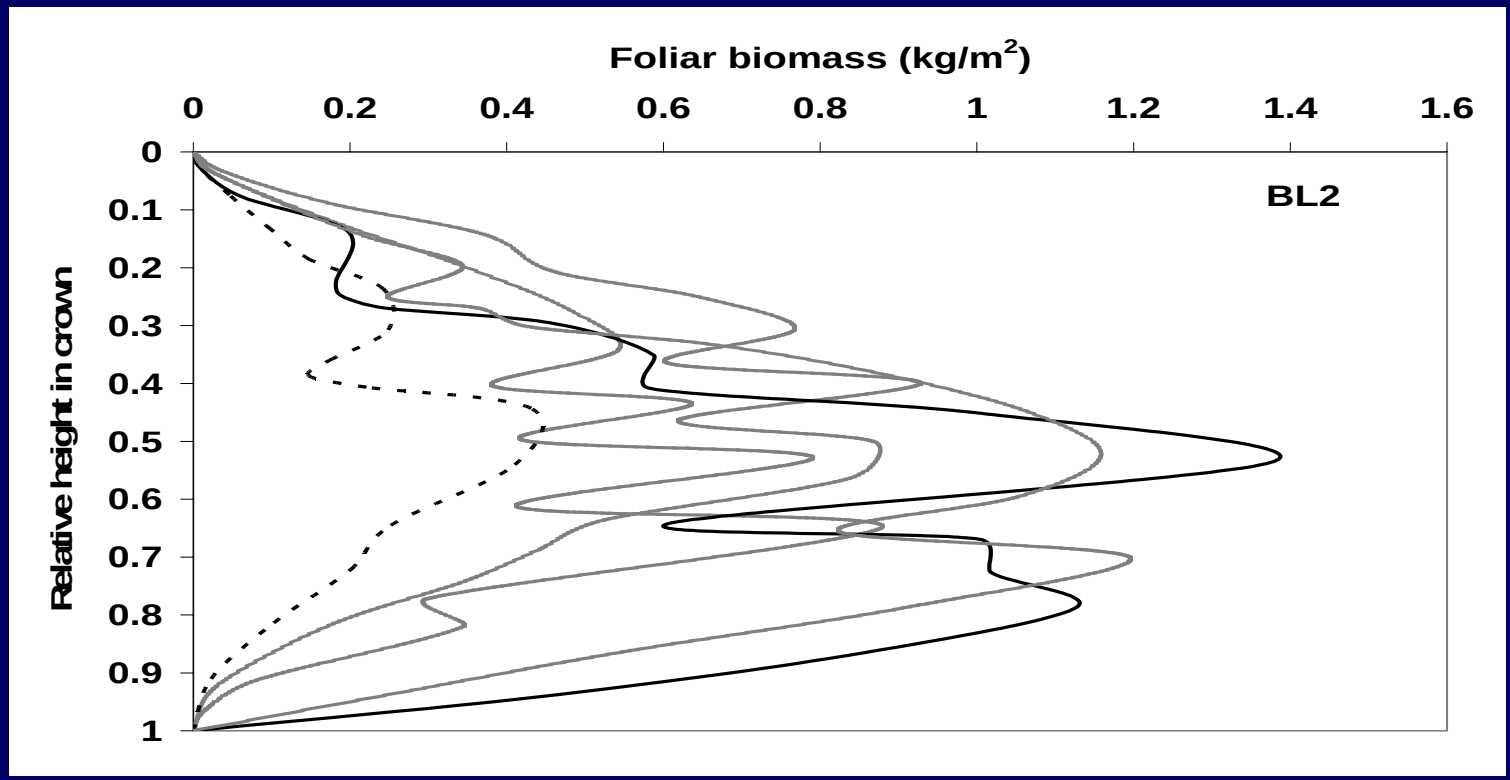

Plot of residuals for Hcr
r
4
3
2
1
0
-1
-2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Hcr

Results ---II

- Vertical distribution (a, b, c are random effects)

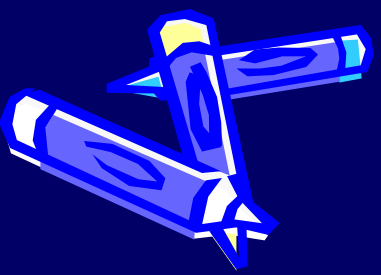
$$B_V = e^{(a)} (L_{RC})^b (1 - L_{RC})^c h^d$$

Results---II

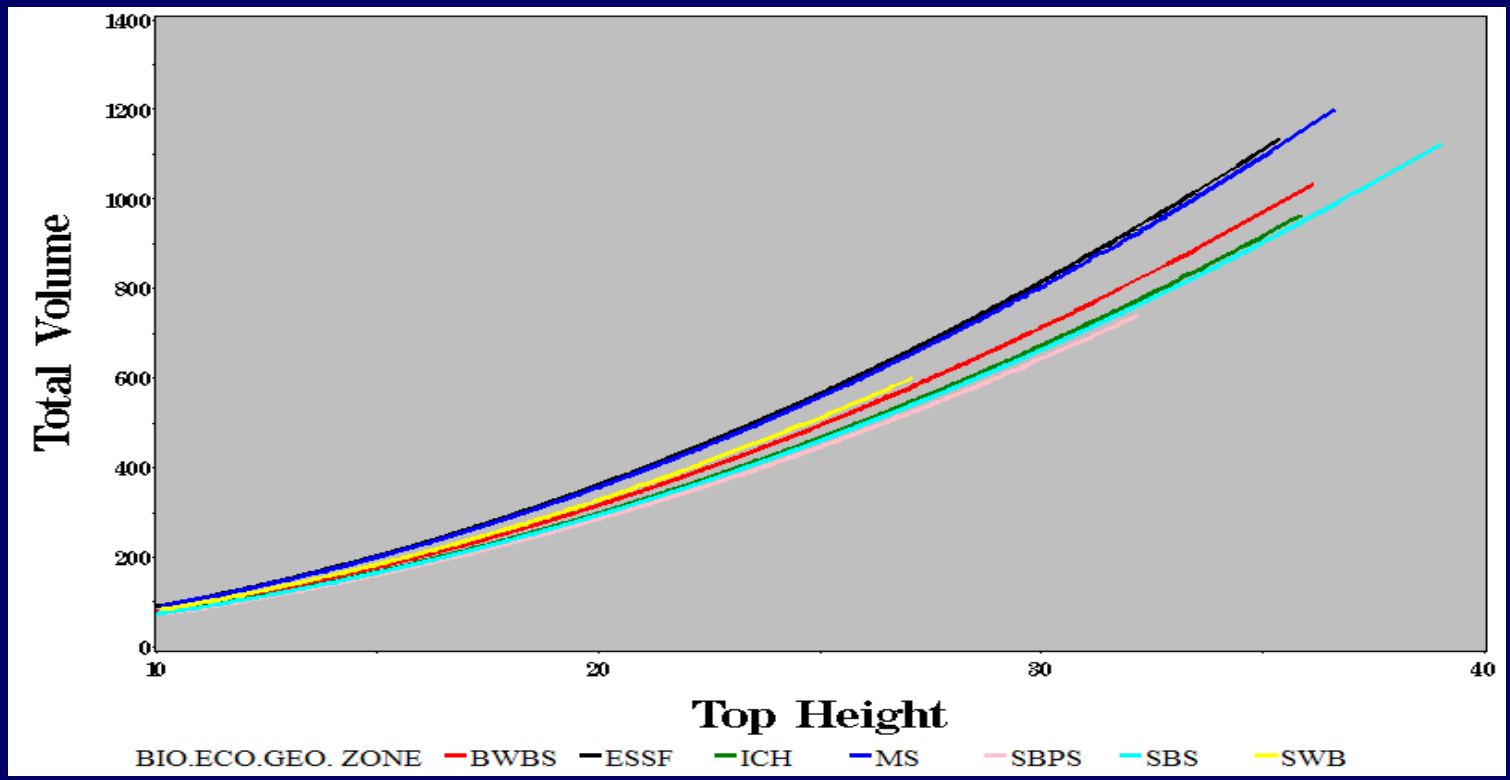

Foliar biomass (kg/m^2)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Relative height in crown
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
BL2

Results---III

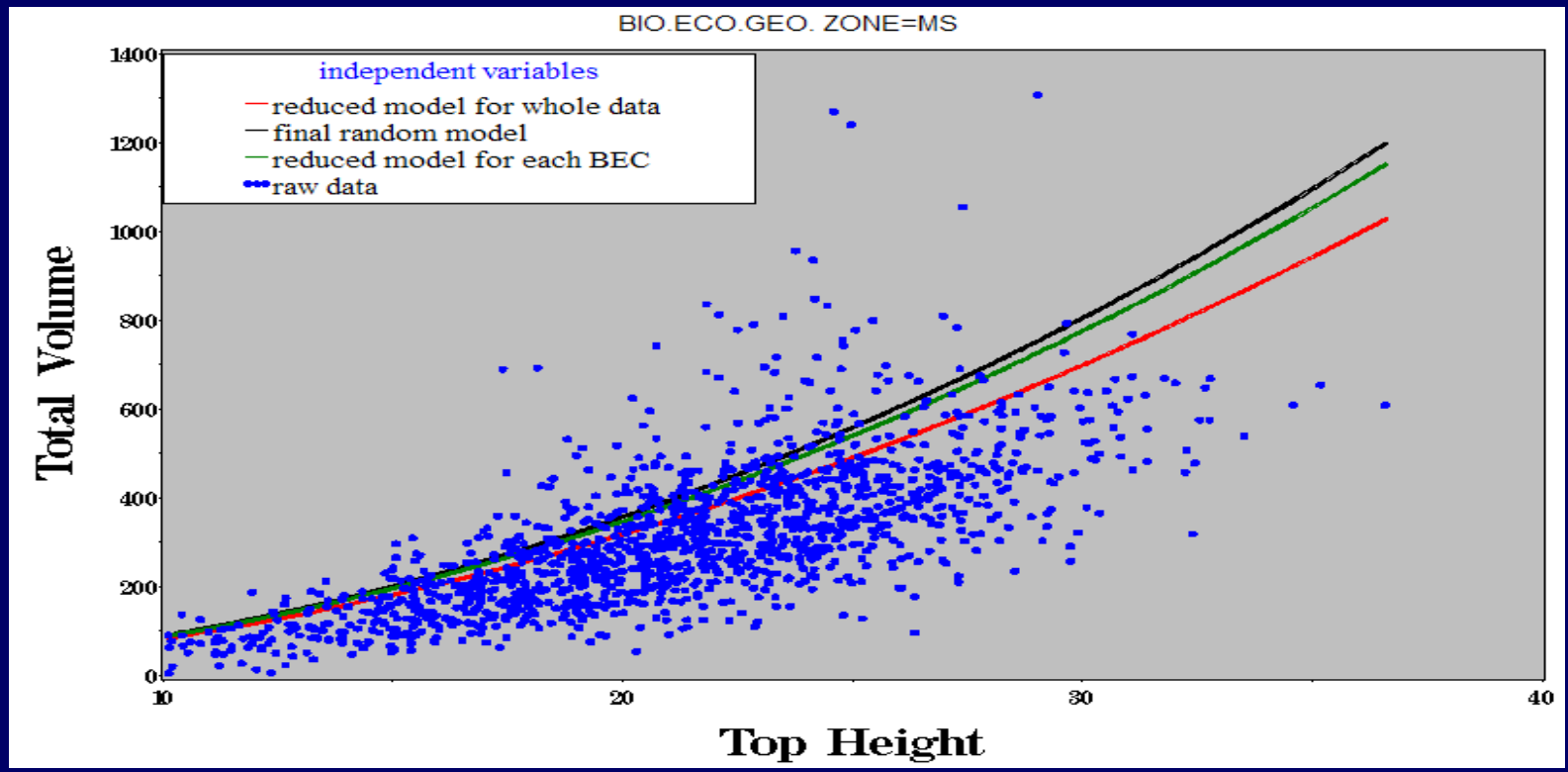
- Height –Volume frontier relationship

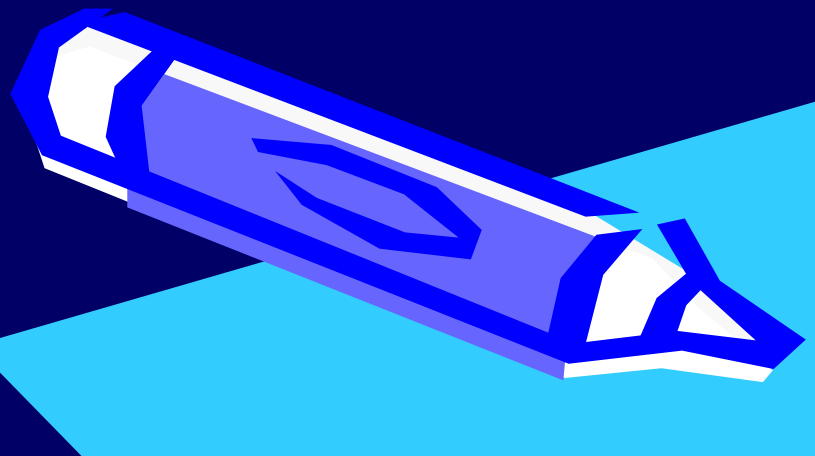


Results---III


Total Volume
1400
1200
1000
800
600
400
200
0
10
20
30
40
Top Height
BIO.ECO.GEO. ZONE
BWBS
ESSF
ICH
MS
SBPS
SBS
SWB

Results---III


BIO.ECO.GEO. ZONE=MS
independent variables
reduced model for whole data
final random model
reduced model for each BEC
raw data
Total Volume
Top Height
0
200
400
600
800
1000
1200
1400
10
20
30
40



Thank you

Questions?