Pb-210 CF:CS Radioisotope Data Analysis

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Code Description

This code is designed to analyze radioisotopic data from sediment core LMG1311 JKC1 collected in 2013 in Antarctica. A non-linear exponential Constant Flux:Constant Sedimentation model (Smith et al., 2017) is fit to excess Pb-210 activity to establish mean sedimentation rates along with 95% confidence intervals. Age-depth models are generated from the sedimentation rates, with uncertainties propograted from 95% CI. All depths in core are porosity-corrected by first calcualting mass accumulation rates (g/cm2/yr) and converting to porosity-corrected sedimentation rates by dividing by depth averages dry-bulk densities. Model results are exported as pdf images and text files.

Smith, J. A., Andersen, T. J., Shortt, M., Gaffney, A. M., Truffer, M., Stanton, T. P., … Vaughan, D. G. (2017). twentieth-century retreat of Pine Island Glacier. Nature Publishing Group, 541(7635), 77–80. <https://doi.org/10.1038/nature20136>

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Load Packages

library(zoo)

##   
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':  
##   
## as.Date, as.Date.numeric

library(MASS)  
library(ggplot2)  
library(gridExtra)  
library(reshape2)  
library(nlstools)

##   
## 'nlstools' has been loaded.

## IMPORTANT NOTICE: Most nonlinear regression models and data set examples

## related to predictive microbiolgy have been moved to the package 'nlsMicrobio'

library(ezknitr)

Initialize with data from the core:

core\_name <- "LMG1311\_JKC1"  
collectyear=2013 #year in CE that core was collected  
countyear=2016 #year in CE that core was counted for radioisotopes  
Depth\_M=c(0.4,1.2,2,2.8,3.6,5.2,6.8,8.5,10.5,13.5,18.5,23.5,33.5)  
Pb210T=c(66.15303314,62.89575353,60.16993251,56.1229667,55.26586492,47.39009405,31.40510612,25.86412078,17.92583009,8.888739124,7.011996368,4.371368536,2.879387116)  
Pb210u=c(0.923975511,1.043404646,1.043855765,1.077380321,0.871133708,0.899180449,0.629698332,0.731284593,0.554923413,0.379968221,0.413155963,0.313522917,0.248186141)  
Ra226=c(6.821091269,5.016832664,5.003393066,5.380786404,4.610007074,5.353152765,5.295144045,7.390493346,5.153360507,5.420436271,4.578162811,4.411351507,4.888541848)  
Ra226U=c(3.326330511,2.170383149,1.85628713,2.386004097,1.694741448,2.654557505,2.557715672,2.11977753,2.053059948,2.398919635,1.810716536,1.487010557,1.910846372)  
DBD=c(0.254175,0.256045,0.26,0.274595,0.36452,0.36572,0.312005,0.28579,0.349225,0.372895,0.20087,0.1829,0.343255)

Set up data output

a=length(Pb210T)  
nmeasures=a[1]  
ageresults=matrix(0,nmeasures,4)  
ageresults[,1]=Depth\_M

# Establish depth range for regression  
ztop=2 # number of first sample at base of surface mixed layer; MAKE SURE THIS NUMBER IS ACCURATE FOR EACH PROFILE  
  
A0=xsPbcor[ztop]#first sample at base of surface mixed layer  
AZ=xsPbcor/A0#normalized activity  
zbot <- nmeasures

# Calculate Cumulative Mass  
cmval <- matrix(0,nmeasures)  
DBDval <- DBD  
depth <- Depth\_M  
dbdmean <- rollmean(DBDval,2)  
for (v in 2:nmeasures ) {  
 cmval[v] <- ((depth[v]-depth[v-1])\*dbdmean[v-1])+cmval[v-1]  
}  
DBDave <- mean(DBDval[3:nmeasures])# average of dry bulk density values excluding top two samples; adjust as necessary to average only the vertically stable part of the profile

activitydata <- data.frame(AZ[ztop:zbot], cmval[ztop:zbot])  
colnames(activitydata) <- c("AZ", "cmval")  
modeltop <-ztop# number of first sample at base of surface mixed layer; MAKE SURE THIS NUMBER IS ACCURATE FOR EACH PROFILE  
modelbot <- 11 #sample number for base of excess activity; avoids using any data points that are at supported levels of Pb-210 activity  
modeldata <- activitydata[modeltop:modelbot,]  
expo.der <- deriv3(~exp(-LS \* cmval),  
 c("LS"),  
 function(cmval, LS) NULL)  
str(expo.der)

## function (cmval, LS)

LS<- lambdaPb/0.1  
start <- list(LS=LS)  
  
expmod <- nls(AZ~expo.der(cmval, LS), data=modeldata, start=start)  
summary(expmod)

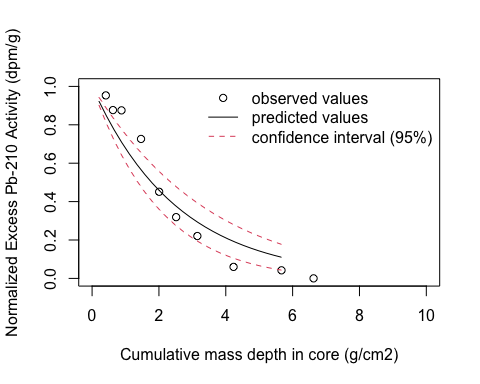
##   
## Formula: AZ ~ expo.der(cmval, LS)  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## LS 0.38905 0.04747 8.196 1.82e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.1097 on 9 degrees of freedom  
##   
## Number of iterations to convergence: 6   
## Achieved convergence tolerance: 4.46e-06

confint(expmod)

## Waiting for profiling to be done...

## 2.5% 97.5%   
## 0.3018547 0.5024520

pred <- data.frame(cmval=seq(cmval[modeltop],cmval[modelbot],l=25))  
der <- do.call(expo.der, args=c(list(cmval=pred$cmval), as.list(coef(expmod))))  
  
F <- attr(der, "gradient")   
U <- chol(vcov(expmod))  
se <- sqrt(apply(F%\*%t(U), 1, function(x) sum(x^2))) #standard error on regression  
  
  
plot(AZ~cmval, data=modeldata,xlab="Cumulative mass depth in core (g/cm2)",  
 ylab="Normalized Excess Pb-210 Activity (dpm/g)",  
 #xlim=c(0,cmval[nmeasures]), ylim=c(0,1))  
 xlim=c(0,10), ylim=c(0,1))  
matlines(pred$cmval, c(der)+  
 outer(se, qt(c(.5, .025,.975), df=df.residual(expmod))),  
 type="l", col=c(1,2,2), lty=c(1,2,2))  
legend("topright",  
 legend=c("observed values", "predicted values",  
 "confidence interval (95%)"),  
 lty=c(NA,1,2), col=c(1,1,2), pch=c(1,NA,NA), bty="n")



#establish range of sed rates  
sedratemid <- massratemid/DBDave #95% CI linear sedimentation rate, data-point estimate (cm/y)  
sedratelow <- massratelow/DBDave #95% CI linear sedimentation rate, low estimate (cm/y)  
sedratehigh <- massratehigh/DBDave #95% CI linear sedimentation rate, high estimate (cm/y)  
ageresults[,2] <- round(collectyear-ageresults[,1]/sedratemid)  
ageresults[,3] <- round(collectyear-ageresults[,1]/sedratelow)  
ageresults[,4] <- round(collectyear-ageresults[,1]/sedratehigh)  
agemodel\_out <- as.data.frame(ageresults)  
colnames(agemodel\_out) <- c("DIC", "agemid","agehigh","agelow")

# plot age-depth data  
agedepth <- ageresults[,1]  
agemid <- ageresults[,2]  
agelow <- ageresults[,4]  
agehigh <- ageresults[,3]  
ageplot <- data.frame(agedepth, agemid, agelow, agehigh)  
ageplotmlt <- melt(ageplot,id.vars="agedepth",measure.vars = c("agemid","agehigh", "agelow"))  
  
#depthmax <-ageplot[nmeasures,1]  
depthmax <-20  
agemax <- 1900  
p1 <- ggplot(ageplotmlt, aes(x = agedepth, y = value, group = variable)) +  
 geom\_line(aes(colour=variable, group=variable), size=1) +  
 scale\_color\_manual(values=c("#000000","#CC6666","#0072B2"))+  
 scale\_x\_continuous(breaks = seq(0, depthmax, 5), limits = c(0, depthmax)) +  
 scale\_y\_continuous(breaks = seq(agemax, 2020, 20), limits = c(agemax, 2020)) +  
 labs(x = "Depth in Core (cm)", y = "Age (Common Era)") +   
 ggtitle(core\_name) +  
 theme(legend.position = c(0.08, 0.35))

## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.  
## ℹ Please use `linewidth` instead.

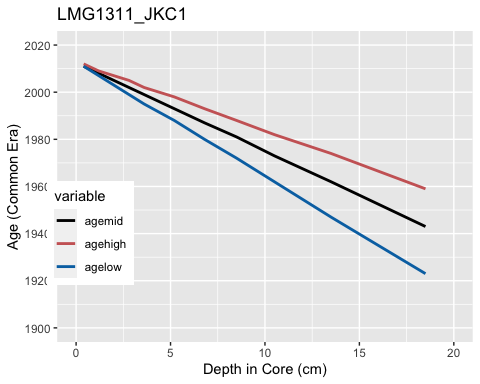
theme\_bw() +  
 theme(panel.background = element\_rect(fill = 'grey95'))+  
 theme(panel.grid.major = element\_line(colour = "black", size=0.5),  
 panel.grid.minor = element\_line(colour = "grey75"),  
 plot.title = element\_text(size = rel(1.1), face = "bold"))

## Warning: The `size` argument of `element\_line()` is deprecated as of ggplot2 3.4.0.  
## ℹ Please use the `linewidth` argument instead.

## List of 94  
## $ line :List of 6  
## ..$ colour : chr "black"  
## ..$ linewidth : num 0.5  
## ..$ linetype : num 1  
## ..$ lineend : chr "butt"  
## ..$ arrow : logi FALSE  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_line" "element"  
## $ rect :List of 5  
## ..$ fill : chr "white"  
## ..$ colour : chr "black"  
## ..$ linewidth : num 0.5  
## ..$ linetype : num 1  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ text :List of 11  
## ..$ family : chr ""  
## ..$ face : chr "plain"  
## ..$ colour : chr "black"  
## ..$ size : num 11  
## ..$ hjust : num 0.5  
## ..$ vjust : num 0.5  
## ..$ angle : num 0  
## ..$ lineheight : num 0.9  
## ..$ margin : 'margin' num [1:4] 0points 0points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : logi FALSE  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ title : NULL  
## $ aspect.ratio : NULL  
## $ axis.title : NULL  
## $ axis.title.x :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 1  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 2.75points 0points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.title.x.top :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 0  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 2.75points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.title.x.bottom : NULL  
## $ axis.title.y :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 1  
## ..$ angle : num 90  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 2.75points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.title.y.left : NULL  
## $ axis.title.y.right :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 0  
## ..$ angle : num -90  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 0points 2.75points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.text :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : chr "grey30"  
## ..$ size : 'rel' num 0.8  
## ..$ hjust : NULL  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.text.x :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 1  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 2.2points 0points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.text.x.top :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : num 0  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 2.2points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.text.x.bottom : NULL  
## $ axis.text.y :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : num 1  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 2.2points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.text.y.left : NULL  
## $ axis.text.y.right :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : num 0  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 0points 2.2points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ axis.ticks :List of 6  
## ..$ colour : chr "grey20"  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ lineend : NULL  
## ..$ arrow : logi FALSE  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_line" "element"  
## $ axis.ticks.x : NULL  
## $ axis.ticks.x.top : NULL  
## $ axis.ticks.x.bottom : NULL  
## $ axis.ticks.y : NULL  
## $ axis.ticks.y.left : NULL  
## $ axis.ticks.y.right : NULL  
## $ axis.ticks.length : 'simpleUnit' num 2.75points  
## ..- attr(\*, "unit")= int 8  
## $ axis.ticks.length.x : NULL  
## $ axis.ticks.length.x.top : NULL  
## $ axis.ticks.length.x.bottom: NULL  
## $ axis.ticks.length.y : NULL  
## $ axis.ticks.length.y.left : NULL  
## $ axis.ticks.length.y.right : NULL  
## $ axis.line : list()  
## ..- attr(\*, "class")= chr [1:2] "element\_blank" "element"  
## $ axis.line.x : NULL  
## $ axis.line.x.top : NULL  
## $ axis.line.x.bottom : NULL  
## $ axis.line.y : NULL  
## $ axis.line.y.left : NULL  
## $ axis.line.y.right : NULL  
## $ legend.background :List of 5  
## ..$ fill : NULL  
## ..$ colour : logi NA  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ legend.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points  
## ..- attr(\*, "unit")= int 8  
## $ legend.spacing : 'simpleUnit' num 11points  
## ..- attr(\*, "unit")= int 8  
## $ legend.spacing.x : NULL  
## $ legend.spacing.y : NULL  
## $ legend.key :List of 5  
## ..$ fill : chr "white"  
## ..$ colour : logi NA  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ legend.key.size : 'simpleUnit' num 1.2lines  
## ..- attr(\*, "unit")= int 3  
## $ legend.key.height : NULL  
## $ legend.key.width : NULL  
## $ legend.text :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : 'rel' num 0.8  
## ..$ hjust : NULL  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ legend.text.align : NULL  
## $ legend.title :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : num 0  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ legend.title.align : NULL  
## $ legend.position : chr "right"  
## $ legend.direction : NULL  
## $ legend.justification : chr "center"  
## $ legend.box : NULL  
## $ legend.box.just : NULL  
## $ legend.box.margin : 'margin' num [1:4] 0cm 0cm 0cm 0cm  
## ..- attr(\*, "unit")= int 1  
## $ legend.box.background : list()  
## ..- attr(\*, "class")= chr [1:2] "element\_blank" "element"  
## $ legend.box.spacing : 'simpleUnit' num 11points  
## ..- attr(\*, "unit")= int 8  
## $ panel.background :List of 5  
## ..$ fill : chr "grey95"  
## ..$ colour : logi NA  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi FALSE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ panel.border :List of 5  
## ..$ fill : logi NA  
## ..$ colour : chr "grey20"  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ panel.spacing : 'simpleUnit' num 5.5points  
## ..- attr(\*, "unit")= int 8  
## $ panel.spacing.x : NULL  
## $ panel.spacing.y : NULL  
## $ panel.grid :List of 6  
## ..$ colour : chr "grey92"  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ lineend : NULL  
## ..$ arrow : logi FALSE  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_line" "element"  
## $ panel.grid.major :List of 6  
## ..$ colour : chr "black"  
## ..$ linewidth : num 0.5  
## ..$ linetype : NULL  
## ..$ lineend : NULL  
## ..$ arrow : logi FALSE  
## ..$ inherit.blank: logi FALSE  
## ..- attr(\*, "class")= chr [1:2] "element\_line" "element"  
## $ panel.grid.minor :List of 6  
## ..$ colour : chr "grey75"  
## ..$ linewidth : 'rel' num 0.5  
## ..$ linetype : NULL  
## ..$ lineend : NULL  
## ..$ arrow : logi FALSE  
## ..$ inherit.blank: logi FALSE  
## ..- attr(\*, "class")= chr [1:2] "element\_line" "element"  
## $ panel.grid.major.x : NULL  
## $ panel.grid.major.y : NULL  
## $ panel.grid.minor.x : NULL  
## $ panel.grid.minor.y : NULL  
## $ panel.ontop : logi FALSE  
## $ plot.background :List of 5  
## ..$ fill : NULL  
## ..$ colour : chr "white"  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ plot.title :List of 11  
## ..$ family : NULL  
## ..$ face : chr "bold"  
## ..$ colour : NULL  
## ..$ size : 'rel' num 1.1  
## ..$ hjust : num 0  
## ..$ vjust : num 1  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 5.5points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi FALSE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ plot.title.position : chr "panel"  
## $ plot.subtitle :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : num 0  
## ..$ vjust : num 1  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 0points 0points 5.5points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ plot.caption :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : 'rel' num 0.8  
## ..$ hjust : num 1  
## ..$ vjust : num 1  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 5.5points 0points 0points 0points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ plot.caption.position : chr "panel"  
## $ plot.tag :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : 'rel' num 1.2  
## ..$ hjust : num 0.5  
## ..$ vjust : num 0.5  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ plot.tag.position : chr "topleft"  
## $ plot.margin : 'margin' num [1:4] 5.5points 5.5points 5.5points 5.5points  
## ..- attr(\*, "unit")= int 8  
## $ strip.background :List of 5  
## ..$ fill : chr "grey85"  
## ..$ colour : chr "grey20"  
## ..$ linewidth : NULL  
## ..$ linetype : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_rect" "element"  
## $ strip.background.x : NULL  
## $ strip.background.y : NULL  
## $ strip.clip : chr "inherit"  
## $ strip.placement : chr "inside"  
## $ strip.text :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : chr "grey10"  
## ..$ size : 'rel' num 0.8  
## ..$ hjust : NULL  
## ..$ vjust : NULL  
## ..$ angle : NULL  
## ..$ lineheight : NULL  
## ..$ margin : 'margin' num [1:4] 4.4points 4.4points 4.4points 4.4points  
## .. ..- attr(\*, "unit")= int 8  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ strip.text.x : NULL  
## $ strip.text.y :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : NULL  
## ..$ angle : num -90  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## $ strip.switch.pad.grid : 'simpleUnit' num 2.75points  
## ..- attr(\*, "unit")= int 8  
## $ strip.switch.pad.wrap : 'simpleUnit' num 2.75points  
## ..- attr(\*, "unit")= int 8  
## $ strip.text.y.left :List of 11  
## ..$ family : NULL  
## ..$ face : NULL  
## ..$ colour : NULL  
## ..$ size : NULL  
## ..$ hjust : NULL  
## ..$ vjust : NULL  
## ..$ angle : num 90  
## ..$ lineheight : NULL  
## ..$ margin : NULL  
## ..$ debug : NULL  
## ..$ inherit.blank: logi TRUE  
## ..- attr(\*, "class")= chr [1:2] "element\_text" "element"  
## - attr(\*, "class")= chr [1:2] "theme" "gg"  
## - attr(\*, "complete")= logi TRUE  
## - attr(\*, "validate")= logi TRUE

p1

## Warning: Removed 6 rows containing missing values (`geom\_line()`).



agemodel\_out

## DIC agemid agehigh agelow  
## 1 0.4 2011 2012 2011  
## 2 1.2 2008 2009 2007  
## 3 2.0 2005 2007 2003  
## 4 2.8 2002 2005 1999  
## 5 3.6 1999 2002 1995  
## 6 5.2 1993 1998 1988  
## 7 6.8 1987 1993 1980  
## 8 8.5 1981 1988 1972  
## 9 10.5 1973 1982 1962  
## 10 13.5 1962 1974 1947  
## 11 18.5 1943 1959 1923  
## 12 23.5 1924 1944 1899  
## 13 33.5 1887 1915 1850

ggsave(paste0(core\_name,".pdf"),   
 p1, width = 6, height = 5)

## Warning: Removed 6 rows containing missing values (`geom\_line()`).

write.csv(agemodel\_out, file=(paste0(core\_name,"modelresults.csv")))