BY-R1

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','byreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,2:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,2:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(1:interiorbreak2);

y2i=y2(1:interiorbreak2);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

t3ii=t(interiorbreak3:end);

y3ii=y3(interiorbreak3:end);

dt = max(t3ii) - min(t3ii);

[interiorbreak3ii,fval3ii] = fminbnd(@(b2) breakfit(b2,t3ii,y3ii),min(t3ii) + dt/100,max(t3ii) - dt/100);

interiorbreak3ii

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(interiorbreak4:end);

y4i=y4(interiorbreak4:end);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

t4ii=t((1:interiorbreak4-15));

y4ii=y4((1:interiorbreak4-15));

dt = max(t4ii) - min(t4ii);

[interiorbreak4ii,fval4ii] = fminbnd(@(b2) breakfit(b2,t4ii,y4ii),min(t4ii) + dt/100,max(t4ii) - dt/100);

interiorbreak4ii

figure(4);

plot(t,y4,'LineWidth',3); hold on;

% plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4ii),y4(round(interiorbreak4ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:(interiorbreak5-10));

y5i=y4(1:(interiorbreak5-10));

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5iii),y5(round(interiorbreak5iii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

t6i=t(1:interiorbreak6);

y6i=y6(1:interiorbreak6);

dt = max(t6i) - min(t6i);

[interiorbreak6i,fval6i] = fminbnd(@(b2) breakfit(b2,t6i,y6i),min(t6i) + dt/100,max(t6i) - dt/100);

interiorbreak6i

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[0.6 0.2 1.0],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[0.55 0.1 0.75],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[0.5 0.0 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.35 0.0 0.45],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4ii),y4(round(interiorbreak4ii+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.25 0.0 0.3],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.15 0.0 0.15],'LineWidth',3); hold on;

h20=plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742 R1\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2

interiorbreak2i

interiorbreak3ii

interiorbreak3i

interiorbreak4ii

interiorbreak4i

interiorbreak5i

interiorbreak5

interiorbreak6i

interiorbreak6

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2i+1))-y2(1))/interiorbreak2i

durationat021=interiorbreak2i

slopeat022=(y2(round(interiorbreak2+1))-y2(round(interiorbreak2i+1)))/(interiorbreak2-interiorbreak2i)

durationat022=interiorbreak2-interiorbreak2i

slopeat023=(y2(end)-y2(round(interiorbreak2+1)))/(t(end)-interiorbreak2)

durationat023=t(end)-interiorbreak2

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3ii+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3ii-interiorbreak3i)

durationat042=interiorbreak3ii-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3ii+1)))/(t(end)-interiorbreak3ii)

durationat043=t(end)-interiorbreak3ii

% concentration 06

slopeat061=(y4(round(interiorbreak4ii+1))-y4(1))/interiorbreak4ii

durationat061=interiorbreak4ii

slopeat062=(y4(round(interiorbreak4i+1))-y4(round(interiorbreak4ii+1)))/(interiorbreak4i-interiorbreak4ii)

durationat062=interiorbreak4i-interiorbreak4ii

slopeat063=(y4(end)-y4(round(interiorbreak4i+1)))/(t(end)-interiorbreak4i)

durationat063=t(end)-interiorbreak4i

% concentration 08

slopeat081=(y5(round(interiorbreak5i+1))-y5(1))/interiorbreak5i

durationat081=interiorbreak5i

slopeat082=(y5(round(interiorbreak5+1))-y5(round(interiorbreak5i+1)))/(interiorbreak5-interiorbreak5i)

durationat082=interiorbreak5-interiorbreak5i

slopeat083=(y5(end)-y5(round(interiorbreak5+1)))/(t(end)-interiorbreak5)

durationat083=t(end)-interiorbreak5

% concentration 10

slopeat101=(y6(round(interiorbreak6i+1))-y6(1))/interiorbreak6i

durationat101=interiorbreak6i

slopeat102=(y6(round(interiorbreak6+1))-y6(round(interiorbreak6i+1)))/(interiorbreak6-interiorbreak6i)

durationat102=interiorbreak6-interiorbreak6i

slopeat103=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat103=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

durationat101

0

durationat022

durationat042

durationat062

durationat082

durationat102

durationat002

durationat023

durationat043

durationat063

durationat083

durationat103

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

slopeat101

0

slopeat022

slopeat042

slopeat062

slopeat082

slopeat102

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

slopeat103

%%

% figure(14);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur1 = [durationat001 durationat021 durationat041 durationat061 durationat081 durationat101];

%

% hb1 = bar(E,dur1,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb1.CData(1,:) = [0.75 1.0 1.0];

% hb1.CData(2,:) = [0.5 0.8 0.8];

% hb1.CData(3,:) = [0.4 0.75 0.6];

% hb1.CData(4,:) = [0.3 0.5 0.4];

% hb1.CData(5,:) = [0.2 0.25 0.3];

% hb1.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D1 (hrs)');

%

% hold off

%

% subplot(2,2,2);

%

% dur2 = [0 durationat022 durationat042 durationat062 durationat082 0];

%

% hb2 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb2.CData(1,:) = [0.75 1.0 1.0];

% hb2.CData(2,:) = [0.5 0.8 0.8];

% hb2.CData(3,:) = [0.4 0.75 0.6];

% hb2.CData(4,:) = [0.3 0.5 0.4];

% hb2.CData(5,:) = [0.2 0.25 0.3];

% hb2.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D2 (hrs)');

%

% subplot(2,2,3);

%

% dur2 = [0 durationat023 durationat043 durationat063 durationat083 0];

%

% hb3 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb3.CData(1,:) = [0.75 1.0 1.0];

% hb3.CData(2,:) = [0.5 0.8 0.8];

% hb3.CData(3,:) = [0.4 0.75 0.6];

% hb3.CData(4,:) = [0.3 0.5 0.4];

% hb3.CData(5,:) = [0.2 0.25 0.3];

% hb3.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D3 (hrs)');

%

% hold off

%

% subplot(2,2,4);

%

% dur2 = [durationat002 durationat024 durationat044 durationat064 durationat084 durationat102];

%

% hb4 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb4.CData(1,:) = [0.75 1.0 1.0];

% hb4.CData(2,:) = [0.5 0.8 0.8];

% hb4.CData(3,:) = [0.4 0.75 0.6];

% hb4.CData(4,:) = [0.3 0.5 0.4];

% hb4.CData(5,:) = [0.2 0.25 0.3];

% hb4.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 75]); xlim ([-0.2 1.2]);

% ylabel('D4 (hrs)');

%

% hold off

% %%

% figure(15);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur5 = [slopeat001 slopeat021 slopeat041 slopeat061 slopeat081 slopeat101];

%

% hb5 = bar(E,dur5,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb5.CData(1,:) = [0.75 1.0 1.0];

% hb5.CData(2,:) = [0.5 0.8 0.8];

% hb5.CData(3,:) = [0.4 0.75 0.6];

% hb5.CData(4,:) = [0.3 0.5 0.4];

% hb5.CData(5,:) = [0.2 0.25 0.3];

% hb5.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.2]); xlim ([-0.2 1.2]);

% ylabel('S1');

%

% hold off

%

% subplot(2,2,2);

%

% dur6 = [0 slopeat022 slopeat042 slopeat062 slopeat082 0];

%

% hb6 = bar(E,dur6,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb6.CData(1,:) = [0.75 1.0 1.0];

% hb6.CData(2,:) = [0.5 0.8 0.8];

% hb6.CData(3,:) = [0.4 0.75 0.6];

% hb6.CData(4,:) = [0.3 0.5 0.4];

% hb6.CData(5,:) = [0.2 0.25 0.3];

% hb6.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.025]); xlim ([-0.2 1.2]);

% ylabel('S2');

%

% subplot(2,2,3);

%

% dur7 = [0 slopeat023 slopeat043 slopeat063 slopeat083 0];

%

% hb7 = bar(E,dur7,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb7.CData(1,:) = [0.75 1.0 1.0];

% hb7.CData(2,:) = [0.5 0.8 0.8];

% hb7.CData(3,:) = [0.4 0.75 0.6];

% hb7.CData(4,:) = [0.3 0.5 0.4];

% hb7.CData(5,:) = [0.2 0.25 0.3];

% hb7.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.002 0.05]); xlim ([-0.2 1.2]);

% ylabel('S3');

%

% hold off

%

% subplot(2,2,4);

%

% dur8 = [slopeat002 slopeat024 slopeat044 slopeat064 slopeat084 slopeat102];

%

% hb8 = bar(E,dur8,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb8.CData(1,:) = [0.75 1.0 1.0];

% hb8.CData(2,:) = [0.5 0.8 0.8];

% hb8.CData(3,:) = [0.4 0.75 0.6];

% hb8.CData(4,:) = [0.3 0.5 0.4];

% hb8.CData(5,:) = [0.2 0.25 0.3];

% hb8.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.01 0.01]); xlim ([-0.2 1.2]);

% ylabel('S4');

%

% hold off

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

durationat101 durationat102 durationat103;];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [0.55 0.1 0.75];

ba(2).CData = [0.35 0.0 0.45];

ba(3).CData = [0.15 0.0 0.15];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end

BY-R2

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','byreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,3:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,3:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(1:interiorbreak2);

y2i=y2(1:interiorbreak2);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

t3ii=t(interiorbreak3:end);

y3ii=y3(interiorbreak3:end);

dt = max(t3ii) - min(t3ii);

[interiorbreak3ii,fval3ii] = fminbnd(@(b2) breakfit(b2,t3ii,y3ii),min(t3ii) + dt/100,max(t3ii) - dt/100);

interiorbreak3ii

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(interiorbreak4:end);

y4i=y4(interiorbreak4:end);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

% t4ii=t(1:interiorbreak4);

% y4ii=y4(1:interiorbreak4);

% dt = max(t4ii) - min(t4ii);

% [interiorbreak4ii,fval4ii] = fminbnd(@(b2) breakfit(b2,t4ii,y4ii),min(t4ii) + dt/100,max(t4ii) - dt/100);

% interiorbreak4ii

figure(4);

plot(t,y4,'LineWidth',3); hold on;

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak4ii),y4(round(interiorbreak4ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:(interiorbreak5-10));

y5i=y4(1:(interiorbreak5-10));

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5iii),y5(round(interiorbreak5iii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

t6i=t(1:interiorbreak6);

y6i=y6(1:interiorbreak6);

dt = max(t6i) - min(t6i);

[interiorbreak6i,fval6i] = fminbnd(@(b2) breakfit(b2,t6i,y6i),min(t6i) + dt/100,max(t6i) - dt/100);

interiorbreak6i

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[0.6 0.2 1.0],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[0.55 0.1 0.75],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[0.5 0.0 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.35 0.0 0.45],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.25 0.0 0.3],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.15 0.0 0.15],'LineWidth',3); hold on;

h20=plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742 R2\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2

interiorbreak2i

interiorbreak3ii

interiorbreak3i

interiorbreak4

interiorbreak4i

interiorbreak5i

interiorbreak5

interiorbreak6i

interiorbreak6

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2i+1))-y2(1))/interiorbreak2i

durationat021=interiorbreak2i

slopeat022=(y2(round(interiorbreak2+1))-y2(round(interiorbreak2i+1)))/(interiorbreak2-interiorbreak2i)

durationat022=interiorbreak2-interiorbreak2i

slopeat023=(y2(end)-y2(round(interiorbreak2+1)))/(t(end)-interiorbreak2)

durationat023=t(end)-interiorbreak2

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3ii+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3ii-interiorbreak3i)

durationat042=interiorbreak3ii-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3ii+1)))/(t(end)-interiorbreak3ii)

durationat043=t(end)-interiorbreak3ii

% concentration 06

slopeat061=(y4(round(interiorbreak4+1))-y4(1))/interiorbreak4

durationat061=interiorbreak4

slopeat062=(y4(round(interiorbreak4i+1))-y4(round(interiorbreak4+1)))/(interiorbreak4i-interiorbreak4)

durationat062=interiorbreak4i-interiorbreak4

slopeat063=(y4(end)-y4(round(interiorbreak4i+1)))/(t(end)-interiorbreak4i)

durationat063=t(end)-interiorbreak4i

% concentration 08

slopeat081=(y5(round(interiorbreak5i+1))-y5(1))/interiorbreak5i

durationat081=interiorbreak5i

slopeat082=(y5(round(interiorbreak5+1))-y5(round(interiorbreak5i+1)))/(interiorbreak5-interiorbreak5i)

durationat082=interiorbreak5-interiorbreak5i

slopeat083=(y5(end)-y5(round(interiorbreak5+1)))/(t(end)-interiorbreak5)

durationat083=t(end)-interiorbreak5

% concentration 10

slopeat101=(y6(round(interiorbreak6i+1))-y6(1))/interiorbreak6i

durationat101=interiorbreak6i

slopeat102=(y6(round(interiorbreak6+1))-y6(round(interiorbreak6i+1)))/(interiorbreak6-interiorbreak6i)

durationat102=interiorbreak6-interiorbreak6i

slopeat103=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat103=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

durationat101

0

durationat022

durationat042

durationat062

durationat082

durationat102

durationat002

durationat023

durationat043

durationat063

durationat083

durationat103

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

slopeat101

0

slopeat022

slopeat042

slopeat062

slopeat082

slopeat102

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

slopeat103

%%

% figure(14);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur1 = [durationat001 durationat021 durationat041 durationat061 durationat081 durationat101];

%

% hb1 = bar(E,dur1,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb1.CData(1,:) = [0.75 1.0 1.0];

% hb1.CData(2,:) = [0.5 0.8 0.8];

% hb1.CData(3,:) = [0.4 0.75 0.6];

% hb1.CData(4,:) = [0.3 0.5 0.4];

% hb1.CData(5,:) = [0.2 0.25 0.3];

% hb1.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D1 (hrs)');

%

% hold off

%

% subplot(2,2,2);

%

% dur2 = [0 durationat022 durationat042 durationat062 durationat082 0];

%

% hb2 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb2.CData(1,:) = [0.75 1.0 1.0];

% hb2.CData(2,:) = [0.5 0.8 0.8];

% hb2.CData(3,:) = [0.4 0.75 0.6];

% hb2.CData(4,:) = [0.3 0.5 0.4];

% hb2.CData(5,:) = [0.2 0.25 0.3];

% hb2.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D2 (hrs)');

%

% subplot(2,2,3);

%

% dur2 = [0 durationat023 durationat043 durationat063 durationat083 0];

%

% hb3 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb3.CData(1,:) = [0.75 1.0 1.0];

% hb3.CData(2,:) = [0.5 0.8 0.8];

% hb3.CData(3,:) = [0.4 0.75 0.6];

% hb3.CData(4,:) = [0.3 0.5 0.4];

% hb3.CData(5,:) = [0.2 0.25 0.3];

% hb3.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D3 (hrs)');

%

% hold off

%

% subplot(2,2,4);

%

% dur2 = [durationat002 durationat024 durationat044 durationat064 durationat084 durationat102];

%

% hb4 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb4.CData(1,:) = [0.75 1.0 1.0];

% hb4.CData(2,:) = [0.5 0.8 0.8];

% hb4.CData(3,:) = [0.4 0.75 0.6];

% hb4.CData(4,:) = [0.3 0.5 0.4];

% hb4.CData(5,:) = [0.2 0.25 0.3];

% hb4.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 75]); xlim ([-0.2 1.2]);

% ylabel('D4 (hrs)');

%

% hold off

% %%

% figure(15);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur5 = [slopeat001 slopeat021 slopeat041 slopeat061 slopeat081 slopeat101];

%

% hb5 = bar(E,dur5,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb5.CData(1,:) = [0.75 1.0 1.0];

% hb5.CData(2,:) = [0.5 0.8 0.8];

% hb5.CData(3,:) = [0.4 0.75 0.6];

% hb5.CData(4,:) = [0.3 0.5 0.4];

% hb5.CData(5,:) = [0.2 0.25 0.3];

% hb5.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.2]); xlim ([-0.2 1.2]);

% ylabel('S1');

%

% hold off

%

% subplot(2,2,2);

%

% dur6 = [0 slopeat022 slopeat042 slopeat062 slopeat082 0];

%

% hb6 = bar(E,dur6,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb6.CData(1,:) = [0.75 1.0 1.0];

% hb6.CData(2,:) = [0.5 0.8 0.8];

% hb6.CData(3,:) = [0.4 0.75 0.6];

% hb6.CData(4,:) = [0.3 0.5 0.4];

% hb6.CData(5,:) = [0.2 0.25 0.3];

% hb6.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.025]); xlim ([-0.2 1.2]);

% ylabel('S2');

%

% subplot(2,2,3);

%

% dur7 = [0 slopeat023 slopeat043 slopeat063 slopeat083 0];

%

% hb7 = bar(E,dur7,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb7.CData(1,:) = [0.75 1.0 1.0];

% hb7.CData(2,:) = [0.5 0.8 0.8];

% hb7.CData(3,:) = [0.4 0.75 0.6];

% hb7.CData(4,:) = [0.3 0.5 0.4];

% hb7.CData(5,:) = [0.2 0.25 0.3];

% hb7.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.002 0.05]); xlim ([-0.2 1.2]);

% ylabel('S3');

%

% hold off

%

% subplot(2,2,4);

%

% dur8 = [slopeat002 slopeat024 slopeat044 slopeat064 slopeat084 slopeat102];

%

% hb8 = bar(E,dur8,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb8.CData(1,:) = [0.75 1.0 1.0];

% hb8.CData(2,:) = [0.5 0.8 0.8];

% hb8.CData(3,:) = [0.4 0.75 0.6];

% hb8.CData(4,:) = [0.3 0.5 0.4];

% hb8.CData(5,:) = [0.2 0.25 0.3];

% hb8.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.01 0.01]); xlim ([-0.2 1.2]);

% ylabel('S4');

%

% hold off

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

durationat101 durationat102 durationat103;];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [0.55 0.1 0.75];

ba(2).CData = [0.35 0.0 0.45];

ba(3).CData = [0.15 0.0 0.15];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end

BY-R3

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','byreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,4:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,4:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(interiorbreak2:end);

y2i=y2(interiorbreak2:end);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

t2ii=t(1:interiorbreak2);

y2ii=y2(1:interiorbreak2);

dt = max(t2ii) - min(t2ii);

[interiorbreak2ii,fval2ii] = fminbnd(@(b2) breakfit(b2,t2ii,y2ii),min(t2ii) + dt/100,max(t2ii) - dt/100);

interiorbreak2ii

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

t3ii=t(interiorbreak3:end);

y3ii=y3(interiorbreak3:end);

dt = max(t3ii) - min(t3ii);

[interiorbreak3ii,fval3ii] = fminbnd(@(b2) breakfit(b2,t3ii,y3ii),min(t3ii) + dt/100,max(t3ii) - dt/100);

interiorbreak3ii

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(1:interiorbreak4);

y4i=y4(1:interiorbreak4);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

% t4ii=t(1:interiorbreak4);

% y4ii=y4(1:interiorbreak4);

% dt = max(t4ii) - min(t4ii);

% [interiorbreak4ii,fval4ii] = fminbnd(@(b2) breakfit(b2,t4ii,y4ii),min(t4ii) + dt/100,max(t4ii) - dt/100);

% interiorbreak4ii

figure(4);

plot(t,y4,'LineWidth',3); hold on;

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak4ii),y4(round(interiorbreak4ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:(interiorbreak5-10));

y5i=y4(1:(interiorbreak5-10));

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak5iii),y5(round(interiorbreak5iii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

t6i=t(1:interiorbreak6);

y6i=y6(1:interiorbreak6);

dt = max(t6i) - min(t6i);

[interiorbreak6i,fval6i] = fminbnd(@(b2) breakfit(b2,t6i,y6i),min(t6i) + dt/100,max(t6i) - dt/100);

interiorbreak6i

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[0.6 0.2 1.0],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[0.55 0.1 0.75],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[0.5 0.0 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3ii),y3(round(interiorbreak3ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.35 0.0 0.45],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.25 0.0 0.3],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5),y5(round(interiorbreak5+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.15 0.0 0.15],'LineWidth',3); hold on;

h20=plot(round(interiorbreak6i),y6(round(interiorbreak6i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742 R3\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2ii

interiorbreak2i

interiorbreak3i

interiorbreak3ii

interiorbreak4i

interiorbreak4

interiorbreak5i

interiorbreak5

interiorbreak6i

interiorbreak6

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2ii+1))-y2(1))/interiorbreak2ii

durationat021=interiorbreak2ii

slopeat022=(y2(round(interiorbreak2i+1))-y2(round(interiorbreak2ii+1)))/(interiorbreak2i-interiorbreak2ii)

durationat022=interiorbreak2i-interiorbreak2ii

slopeat023=(y2(end)-y2(round(interiorbreak2i+1)))/(t(end)-interiorbreak2i)

durationat023=t(end)-interiorbreak2i

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3ii+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3ii-interiorbreak3i)

durationat042=interiorbreak3ii-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3ii+1)))/(t(end)-interiorbreak3ii)

durationat043=t(end)-interiorbreak3ii

% concentration 06

slopeat061=(y4(round(interiorbreak4i+1))-y4(1))/interiorbreak4i

durationat061=interiorbreak4i

slopeat062=(y4(round(interiorbreak4+1))-y4(round(interiorbreak4i+1)))/(interiorbreak4-interiorbreak4i)

durationat062=interiorbreak4-interiorbreak4i

slopeat063=(y4(end)-y4(round(interiorbreak4+1)))/(t(end)-interiorbreak4)

durationat063=t(end)-interiorbreak4

% concentration 08

slopeat081=(y5(round(interiorbreak5i+1))-y5(1))/interiorbreak5i

durationat081=interiorbreak5i

slopeat082=(y5(round(interiorbreak5+1))-y5(round(interiorbreak5i+1)))/(interiorbreak5-interiorbreak5i)

durationat082=interiorbreak5-interiorbreak5i

slopeat083=(y5(end)-y5(round(interiorbreak5+1)))/(t(end)-interiorbreak5)

durationat083=t(end)-interiorbreak5

% concentration 10

slopeat101=(y6(round(interiorbreak6i+1))-y6(1))/interiorbreak6i

durationat101=interiorbreak6i

slopeat102=(y6(round(interiorbreak6+1))-y6(round(interiorbreak6i+1)))/(interiorbreak6-interiorbreak6i)

durationat102=interiorbreak6-interiorbreak6i

slopeat103=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat103=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

durationat101

0

durationat022

durationat042

durationat062

durationat082

durationat102

durationat002

durationat023

durationat043

durationat063

durationat083

durationat103

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

slopeat101

0

slopeat022

slopeat042

slopeat062

slopeat082

slopeat102

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

slopeat103

%%

% figure(14);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur1 = [durationat001 durationat021 durationat041 durationat061 durationat081 durationat101];

%

% hb1 = bar(E,dur1,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb1.CData(1,:) = [0.75 1.0 1.0];

% hb1.CData(2,:) = [0.5 0.8 0.8];

% hb1.CData(3,:) = [0.4 0.75 0.6];

% hb1.CData(4,:) = [0.3 0.5 0.4];

% hb1.CData(5,:) = [0.2 0.25 0.3];

% hb1.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D1 (hrs)');

%

% hold off

%

% subplot(2,2,2);

%

% dur2 = [0 durationat022 durationat042 durationat062 durationat082 0];

%

% hb2 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb2.CData(1,:) = [0.75 1.0 1.0];

% hb2.CData(2,:) = [0.5 0.8 0.8];

% hb2.CData(3,:) = [0.4 0.75 0.6];

% hb2.CData(4,:) = [0.3 0.5 0.4];

% hb2.CData(5,:) = [0.2 0.25 0.3];

% hb2.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D2 (hrs)');

%

% subplot(2,2,3);

%

% dur2 = [0 durationat023 durationat043 durationat063 durationat083 0];

%

% hb3 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb3.CData(1,:) = [0.75 1.0 1.0];

% hb3.CData(2,:) = [0.5 0.8 0.8];

% hb3.CData(3,:) = [0.4 0.75 0.6];

% hb3.CData(4,:) = [0.3 0.5 0.4];

% hb3.CData(5,:) = [0.2 0.25 0.3];

% hb3.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 25]); xlim ([-0.2 1.2]);

% ylabel('D3 (hrs)');

%

% hold off

%

% subplot(2,2,4);

%

% dur2 = [durationat002 durationat024 durationat044 durationat064 durationat084 durationat102];

%

% hb4 = bar(E,dur2,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb4.CData(1,:) = [0.75 1.0 1.0];

% hb4.CData(2,:) = [0.5 0.8 0.8];

% hb4.CData(3,:) = [0.4 0.75 0.6];

% hb4.CData(4,:) = [0.3 0.5 0.4];

% hb4.CData(5,:) = [0.2 0.25 0.3];

% hb4.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 75]); xlim ([-0.2 1.2]);

% ylabel('D4 (hrs)');

%

% hold off

% %%

% figure(15);

% subplot(2,2,1);

%

% E = [0 0.2 0.4 0.6 0.8 1];

% dur5 = [slopeat001 slopeat021 slopeat041 slopeat061 slopeat081 slopeat101];

%

% hb5 = bar(E,dur5,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb5.CData(1,:) = [0.75 1.0 1.0];

% hb5.CData(2,:) = [0.5 0.8 0.8];

% hb5.CData(3,:) = [0.4 0.75 0.6];

% hb5.CData(4,:) = [0.3 0.5 0.4];

% hb5.CData(5,:) = [0.2 0.25 0.3];

% hb5.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.2]); xlim ([-0.2 1.2]);

% ylabel('S1');

%

% hold off

%

% subplot(2,2,2);

%

% dur6 = [0 slopeat022 slopeat042 slopeat062 slopeat082 0];

%

% hb6 = bar(E,dur6,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb6.CData(1,:) = [0.75 1.0 1.0];

% hb6.CData(2,:) = [0.5 0.8 0.8];

% hb6.CData(3,:) = [0.4 0.75 0.6];

% hb6.CData(4,:) = [0.3 0.5 0.4];

% hb6.CData(5,:) = [0.2 0.25 0.3];

% hb6.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([0 0.025]); xlim ([-0.2 1.2]);

% ylabel('S2');

%

% subplot(2,2,3);

%

% dur7 = [0 slopeat023 slopeat043 slopeat063 slopeat083 0];

%

% hb7 = bar(E,dur7,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb7.CData(1,:) = [0.75 1.0 1.0];

% hb7.CData(2,:) = [0.5 0.8 0.8];

% hb7.CData(3,:) = [0.4 0.75 0.6];

% hb7.CData(4,:) = [0.3 0.5 0.4];

% hb7.CData(5,:) = [0.2 0.25 0.3];

% hb7.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.002 0.05]); xlim ([-0.2 1.2]);

% ylabel('S3');

%

% hold off

%

% subplot(2,2,4);

%

% dur8 = [slopeat002 slopeat024 slopeat044 slopeat064 slopeat084 slopeat102];

%

% hb8 = bar(E,dur8,'FaceColor','flat','EdgeColor','k','LineWidth',3);

%

% hb8.CData(1,:) = [0.75 1.0 1.0];

% hb8.CData(2,:) = [0.5 0.8 0.8];

% hb8.CData(3,:) = [0.4 0.75 0.6];

% hb8.CData(4,:) = [0.3 0.5 0.4];

% hb8.CData(5,:) = [0.2 0.25 0.3];

% hb8.CData(6,:) = [0.1 0.0 0.2];

%

% set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

% pbaspect([2 1 1]); ylim([-0.01 0.01]); xlim ([-0.2 1.2]);

% ylabel('S4');

%

% hold off

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

durationat101 durationat102 durationat103;];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [0.55 0.1 0.75];

ba(2).CData = [0.35 0.0 0.45];

ba(3).CData = [0.15 0.0 0.15];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end

YBR-R1

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','ybrreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,2:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,2:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(1:interiorbreak2);

y2i=y2(1:interiorbreak2);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(1:interiorbreak4);

y4i=y4(1:interiorbreak4);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

figure(4);

plot(t,y4,'LineWidth',3); hold on;

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:interiorbreak5);

y5i=y4(1:interiorbreak5);

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

t5ii=t((interiorbreak5i+8):interiorbreak5);

y5ii=y4((interiorbreak5i+8):interiorbreak5);

dt = max(t5ii) - min(t5ii);

[interiorbreak5ii,fval5ii] = fminbnd(@(b2) breakfit(b2,t5ii,y5ii),min(t5ii) + dt/100,max(t5ii) - dt/100);

interiorbreak5ii

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[1.0 0.8 0.8],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[1.0 0.6 0.6],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[1.0 0.2 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.8 0.2 0.4],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.6 0.2 0.4],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.4 0.0 0.2],'LineWidth',3); hold on;

h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742\Deltaa R1\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2i

interiorbreak2

interiorbreak3i

interiorbreak3

interiorbreak4i

interiorbreak4

interiorbreak5i

interiorbreak5ii

interiorbreak6

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2i+1))-y2(1))/interiorbreak2i

durationat021=interiorbreak2i

slopeat022=(y2(round(interiorbreak2+1))-y2(round(interiorbreak2i+1)))/(interiorbreak2-interiorbreak2i)

durationat022=interiorbreak2-interiorbreak2i

slopeat023=(y2(end)-y2(round(interiorbreak2+1)))/(t(end)-interiorbreak2)

durationat023=t(end)-interiorbreak2

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3-interiorbreak3i)

durationat042=interiorbreak3-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3+1)))/(t(end)-interiorbreak3)

durationat043=t(end)-interiorbreak3

% concentration 06

slopeat061=(y4(round(interiorbreak4i+1))-y4(1))/interiorbreak4i

durationat061=interiorbreak4i

slopeat062=(y4(round(interiorbreak4+1))-y4(round(interiorbreak4i+1)))/(interiorbreak4-interiorbreak4i)

durationat062=interiorbreak4-interiorbreak4i

slopeat063=(y4(end)-y4(round(interiorbreak4+1)))/(t(end)-interiorbreak4)

durationat063=t(end)-interiorbreak4

% concentration 08

slopeat081=(y5(round(interiorbreak5i+1))-y5(1))/interiorbreak5i

durationat081=interiorbreak5i

slopeat082=(y5(round(interiorbreak5ii+1))-y5(round(interiorbreak5i+1)))/(interiorbreak5ii-interiorbreak5i)

durationat082=interiorbreak5ii-interiorbreak5i

slopeat083=(y5(end)-y5(round(interiorbreak5ii+1)))/(t(end)-interiorbreak5ii)

durationat083=t(end)-interiorbreak5ii

% concentration 10

slopeat101=(y6(round(interiorbreak6+1))-y6(1))/interiorbreak6

durationat101=interiorbreak6

slopeat102=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat102=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

durationat101

0

durationat022

durationat042

durationat062

durationat082

durationat102

durationat002

durationat023

durationat043

durationat063

durationat083

0

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

slopeat101

0

slopeat022

slopeat042

slopeat062

slopeat082

slopeat102

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

0

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

durationat101 durationat102 0;];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [1.0 0.6 0.6];

ba(2).CData = [0.8 0.2 0.4];

ba(3).CData = [0.4 0.0 0.2];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end

YBR-R2

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','ybrreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,3:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,3:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(1:interiorbreak2);

y2i=y2(1:interiorbreak2);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(1:interiorbreak4);

y4i=y4(1:interiorbreak4);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

figure(4);

plot(t,y4,'LineWidth',3); hold on;

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:interiorbreak5);

y5i=y4(1:interiorbreak5);

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

t5ii=t((interiorbreak5i+5):interiorbreak5);

y5ii=y4((interiorbreak5i+5):interiorbreak5);

dt = max(t5ii) - min(t5ii);

[interiorbreak5ii,fval5ii] = fminbnd(@(b2) breakfit(b2,t5ii,y5ii),min(t5ii) + dt/100,max(t5ii) - dt/100);

interiorbreak5ii

t5iii=t(1:(interiorbreak5-10));

y5iii=y4(1:(interiorbreak5-10));

dt = max(t5iii) - min(t5iii);

[interiorbreak5iii,fval5iii] = fminbnd(@(b2) breakfit(b2,t5iii,y5iii),min(t5iii) + dt/100,max(t5iii) - dt/100);

interiorbreak5iii

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5iii),y5(round(interiorbreak5iii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[1.0 0.8 0.8],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[1.0 0.6 0.6],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[1.0 0.2 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.8 0.2 0.4],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.6 0.2 0.4],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5iii),y5(round(interiorbreak5iii+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.4 0.0 0.2],'LineWidth',3); hold on;

h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742\Deltaa R2\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2i

interiorbreak2

interiorbreak3i

interiorbreak3

interiorbreak4i

interiorbreak4

interiorbreak5iii

interiorbreak5ii

interiorbreak6

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2i+1))-y2(1))/interiorbreak2i

durationat021=interiorbreak2i

slopeat022=(y2(round(interiorbreak2+1))-y2(round(interiorbreak2i+1)))/(interiorbreak2-interiorbreak2i)

durationat022=interiorbreak2-interiorbreak2i

slopeat023=(y2(end)-y2(round(interiorbreak2+1)))/(t(end)-interiorbreak2)

durationat023=t(end)-interiorbreak2

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3-interiorbreak3i)

durationat042=interiorbreak3-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3+1)))/(t(end)-interiorbreak3)

durationat043=t(end)-interiorbreak3

% concentration 06

slopeat061=(y4(round(interiorbreak4i+1))-y4(1))/interiorbreak4i

durationat061=interiorbreak4i

slopeat062=(y4(round(interiorbreak4+1))-y4(round(interiorbreak4i+1)))/(interiorbreak4-interiorbreak4i)

durationat062=interiorbreak4-interiorbreak4i

slopeat063=(y4(end)-y4(round(interiorbreak4+1)))/(t(end)-interiorbreak4)

durationat063=t(end)-interiorbreak4

% concentration 08

slopeat081=(y5(round(interiorbreak5iii+1))-y5(1))/interiorbreak5iii

durationat081=interiorbreak5iii

slopeat082=(y5(round(interiorbreak5ii+1))-y5(round(interiorbreak5iii+1)))/(interiorbreak5ii-interiorbreak5iii)

durationat082=interiorbreak5ii-interiorbreak5iii

slopeat083=(y5(end)-y5(round(interiorbreak5ii+1)))/(t(end)-interiorbreak5ii)

durationat083=t(end)-interiorbreak5ii

% concentration 10

slopeat101=(y6(round(interiorbreak6+1))-y6(1))/interiorbreak6

durationat101=interiorbreak6

slopeat102=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat102=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

durationat101

0

durationat022

durationat042

durationat062

durationat082

durationat102

durationat002

durationat023

durationat043

durationat063

durationat083

0

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

slopeat101

0

slopeat022

slopeat042

slopeat062

slopeat082

slopeat102

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

0

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

durationat101 durationat102 0];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [1.0 0.6 0.6];

ba(2).CData = [0.8 0.2 0.4];

ba(3).CData = [0.4 0.0 0.2];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end

YBR-R3

% Developed on: April 23, 2020

% Description:

% This script performs piecewise exponential growth curve fitting

clearvars; close all;

[num,txt,raw]=xlsread('Lesia2020\_BYflcRESUSP.xlsx','ybrreplicates');

amb=num(1,:);amb=amb(~isnan(amb)); %amB concentrations

mw=num(3:74,4:4:end); %row3 thru 74, column 2 with interval 4 thru end of numbers

ma=num(3:74,4:4:end);

sw=num(3:74,6:8:end);

sa=num(3:74,7:8:end);

t=1:length(mw);

t=t'-1;

y1=log(mw(:,1));

y2=log(mw(:,2));

y3=log(mw(:,3));

y4=log(mw(:,4));

y5=log(mw(:,5));

y6=log(mw(:,6));

%% concentration 0.00

dt = max(t) - min(t);

[interiorbreak1,fval1] = fminbnd(@(b2) breakfit(b2,t,y1),min(t) + dt/100,max(t) - dt/100);

interiorbreak1

figure(1);

plot(t,y1,'LineWidth',3); hold on;

plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');ylim([-2 1]);xlim([-4 77]);

pbaspect([1 1 1]);box on;

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.02

dt = max(t) - min(t);

[interiorbreak2,fval2] = fminbnd(@(b2) breakfit(b2,t,y2),min(t) + dt/100,max(t) - dt/100);

interiorbreak2

t2i=t(1:interiorbreak2);

y2i=y2(1:interiorbreak2);

dt = max(t2i) - min(t2i);

[interiorbreak2i,fval2i] = fminbnd(@(b2) breakfit(b2,t2i,y2i),min(t2i) + dt/100,max(t2i) - dt/100);

interiorbreak2i

figure(2);

plot(t,y2,'LineWidth',3); hold on;

plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12);

% plot(round(interiorbreak2ii),y2(round(interiorbreak2ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.04

dt = max(t) - min(t);

[interiorbreak3,fval3] = fminbnd(@(b2) breakfit(b2,t,y3),min(t) + dt/100,max(t) - dt/100);

interiorbreak3

t3i=t(1:interiorbreak3);

y3i=y3(1:interiorbreak3);

dt = max(t3i) - min(t3i);

[interiorbreak3i,fval3i] = fminbnd(@(b2) breakfit(b2,t3i,y3i),min(t3i) + dt/100,max(t3i) - dt/100);

interiorbreak3i

figure(3);

plot(t,y3,'LineWidth',3); hold on;

plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.06

dt = max(t) - min(t);

[interiorbreak4,fval4] = fminbnd(@(b2) breakfit(b2,t,y4),min(t) + dt/100,max(t) - dt/100);

interiorbreak4

t4i=t(1:interiorbreak4);

y4i=y4(1:interiorbreak4);

dt = max(t4i) - min(t4i);

[interiorbreak4i,fval4i] = fminbnd(@(b2) breakfit(b2,t4i,y4i),min(t4i) + dt/100,max(t4i) - dt/100);

interiorbreak4i

figure(4);

plot(t,y4,'LineWidth',3); hold on;

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.08

dt = max(t) - min(t);

[interiorbreak5,fval5] = fminbnd(@(b2) breakfit(b2,t,y5),min(t) + dt/100,max(t) - dt/100);

interiorbreak5

t5i=t(1:interiorbreak5);

y5i=y4(1:interiorbreak5);

dt = max(t5i) - min(t5i);

[interiorbreak5i,fval5i] = fminbnd(@(b2) breakfit(b2,t5i,y5i),min(t5i) + dt/100,max(t5i) - dt/100);

interiorbreak5i

t5ii=t((interiorbreak5+19):end);

y5ii=y4((interiorbreak5+19):end);

dt = max(t5ii) - min(t5ii);

[interiorbreak5ii,fval5ii] = fminbnd(@(b2) breakfit(b2,t5ii,y5ii),min(t5ii) + dt/100,max(t5ii) - dt/100);

interiorbreak5ii

figure(5);

plot(t,y5,'LineWidth',3); hold on;

plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% concentration 0.1

dt = max(t) - min(t);

[interiorbreak6,fval6] = fminbnd(@(b2) breakfit(b2,t,y6),min(t) + dt/100,max(t) - dt/100);

interiorbreak6

figure(6);

plot(t,y6,'LineWidth',3); hold on;

plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12);

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');pbaspect([1 1 1]);box on;ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)');ylabel('log(OD\_{600})');

%% plot the ultimate result

figure(7);

h1=plot(t,y1,'color',[1.0 0.8 0.8],'LineWidth',3); hold on;

h2=plot(round(interiorbreak1),y1(round(interiorbreak1+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h3=plot(t,y2,'color',[1.0 0.6 0.6],'LineWidth',3); hold on;

h4=plot(round(interiorbreak2i),y2(round(interiorbreak2i+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h5=plot(round(interiorbreak2),y2(round(interiorbreak2+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

h7=plot(t,y3,'color',[1.0 0.2 0.6],'LineWidth',3); hold on;

h8=plot(round(interiorbreak3),y3(round(interiorbreak3+1)),'ko','LineWidth',3,'MarkerSize',12);

h9=plot(round(interiorbreak3i),y3(round(interiorbreak3i+1)),'ko','LineWidth',3,'MarkerSize',12);

h11=plot(t,y4,'color',[0.8 0.2 0.4],'LineWidth',3); hold on;

h12=plot(round(interiorbreak4i),y4(round(interiorbreak4i+1)),'ko','LineWidth',3,'MarkerSize',12);

plot(round(interiorbreak4),y4(round(interiorbreak4+1)),'ko','LineWidth',3,'MarkerSize',12);

h15=plot(t,y5,'color',[0.6 0.2 0.4],'LineWidth',3); hold on;

h16=plot(round(interiorbreak5i),y5(round(interiorbreak5i+1)),'ko','LineWidth',3,'MarkerSize',12);

h17=plot(round(interiorbreak5ii),y5(round(interiorbreak5ii+1)),'ko','LineWidth',3,'MarkerSize',12);

h19=plot(t,y6,'color',[0.4 0.0 0.2],'LineWidth',3); hold on;

% h17=plot(round(interiorbreak6),y6(round(interiorbreak6+1)),'ko','LineWidth',3,'MarkerSize',12); % 1

set(gca,'color',[0.8 0.8 0.8],'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k');

pbaspect([1 1 1]); box on; ylim([-2 1]);xlim([-4 77]);

xlabel('Time (hrs)'); ylabel('log(OD\_{600})'); title ('BY4742\Deltaa R3\_{RESUSP.}');

legend([h1 h3 h7 h11 h15 h19],{'0','50','75','100','125','150 \mug/ml FLC'},'Location','northeastoutside','EdgeColor','none');

interiorbreak1

interiorbreak2i

interiorbreak2

interiorbreak3i

interiorbreak3

interiorbreak4i

interiorbreak4

interiorbreak5i

interiorbreak5ii

%% slopes and durations of all growth phases

% concentration 00

slopeat001=(y1(round(interiorbreak1+1))-y1(1))/interiorbreak1

durationat001=interiorbreak1

slopeat002=(y1(end)-y1(round(interiorbreak1+1)))/(t(end)-interiorbreak1)

durationat002=t(end)-interiorbreak1

% concentration 02

slopeat021=(y2(round(interiorbreak2i+1))-y2(1))/interiorbreak2i

durationat021=interiorbreak2i

slopeat022=(y2(round(interiorbreak2+1))-y2(round(interiorbreak2i+1)))/(interiorbreak2-interiorbreak2i)

durationat022=interiorbreak2-interiorbreak2i

slopeat023=(y2(end)-y2(round(interiorbreak2+1)))/(t(end)-interiorbreak2)

durationat023=t(end)-interiorbreak2

% concentration 04

slopeat041=(y3(round(interiorbreak3i+1))-y3(1))/interiorbreak3i

durationat041=interiorbreak3i

slopeat042=(y3(round(interiorbreak3+1))-y3(round(interiorbreak3i+1)))/(interiorbreak3-interiorbreak3i)

durationat042=interiorbreak3-interiorbreak3i

slopeat043=(y3(end)-y3(round(interiorbreak3+1)))/(t(end)-interiorbreak3)

durationat043=t(end)-interiorbreak3

% concentration 06

slopeat061=(y4(round(interiorbreak4i+1))-y4(1))/interiorbreak4i

durationat061=interiorbreak4i

slopeat062=(y4(round(interiorbreak4+1))-y4(round(interiorbreak4i+1)))/(interiorbreak4-interiorbreak4i)

durationat062=interiorbreak4-interiorbreak4i

slopeat063=(y4(end)-y4(round(interiorbreak4+1)))/(t(end)-interiorbreak4)

durationat063=t(end)-interiorbreak4

% concentration 08

slopeat081=(y5(round(interiorbreak5i+1))-y5(1))/interiorbreak5i

durationat081=interiorbreak5i

slopeat082=(y5(round(interiorbreak5ii+1))-y5(round(interiorbreak5i+1)))/(interiorbreak5ii-interiorbreak5i)

durationat082=interiorbreak5ii-interiorbreak5i

slopeat083=(y5(end)-y5(round(interiorbreak5ii+1)))/(t(end)-interiorbreak5ii)

durationat083=t(end)-interiorbreak5ii

% concentration 10

slopeat101=(y6(round(interiorbreak6+1))-y6(1))/interiorbreak6

durationat101=interiorbreak6

slopeat102=(y1(end)-y6(round(interiorbreak6+1)))/(t(end)-interiorbreak6)

durationat102=t(end)-interiorbreak6

%%

durationat001

durationat021

durationat041

durationat061

durationat081

71

0

durationat022

durationat042

durationat062

durationat082

0

durationat002

durationat023

durationat043

durationat063

durationat083

0

%%

slopeat001

slopeat021

slopeat041

slopeat061

slopeat081

71

0

slopeat022

slopeat042

slopeat062

slopeat082

0

slopeat002

slopeat023

slopeat043

slopeat063

slopeat083

0

%%

figure(8);

% subplot(2,2,1);

hold on

Y = [durationat001 0 durationat002;

durationat021 durationat022 durationat023;

durationat041 durationat042 durationat043;

durationat061 durationat062 durationat063;

durationat081 durationat082 durationat083;

71 0 0];

ba=bar(Y,'stacked','FaceColor','flat','LineWidth',3);

XTickLabel={'a','b','c','d','e','f'};

XTick=[1:6];

set(gca, 'XTick',XTick);

set(gca, 'XTickLabel', XTickLabel);

set(gca, 'XTickLabelRotation', 45);

ba(1).CData = [1.0 0.6 0.6];

ba(2).CData = [0.8 0.2 0.4];

ba(3).CData = [0.4 0.0 0.2];

set(gca,'FontSize',24,'LineWidth',3,'fontname','arial','xcolor','k','ycolor','k','XTickLabel',{'0','50','75','100','125','150'}); box on;

legend('B1','B2','B3','Location','northeastoutside','EdgeColor','none'); ylabel('Break Time (hrs)'); ylim([0 80]);

pbaspect([1 1 1]);

hold off

%%

function [err,fittedlines] = breakfit(interiorbreaks,x,y)

% objective function to estimate the interior break of a simple broken

% line fit. fittedlines is a cell array, containing the slope and

% intercepts of the pair of fitted lines.

% ensure that x and y are column vectors.

x = x(:);

y = y(:);

nx = numel(x);

breaks = [min(x),interiorbreaks,max(x)];

% which points lie in which interval?

xbins = discretize(x,breaks);

% write the problem in matrix form

A = [ones(nx,1),x - breaks(1),(x - breaks(2)).\*(xbins == 2)];

% we could use pinv here, but it would be slower then backslash,

% and I'll be careful to ensure the problem is not singular.

coef = A\y;

err = norm(y - A\*coef);

% unpack the coefficients so we can convert to a pair of line

% coefficients. I'll do this in a fairly long form so it might be more

% comprehensible.

c1 = coef(1);

s1 = coef(2);

s2 = coef(3);

b1 = breaks(1);

b2 = breaks(2);

fittedlines = {[s1,c1 - b1\*s1],[s2 + s1,c1 - b2\*s2]};

end