

```

> restart; interface(rtablesize=350):
with(plots):
with(StringTools):
with(LinearAlgebra):
with(DEtools):

fdisplay:=proc(f,p)
  print(cat(f,`.jpg`)); #print(cat(f,`.eps`));
  plotsetup(jpeg,plotoutput=cat(f,`.jpg`),plotoptions=`noborder`); print(display(p));
  plotsetup(ps,plotoutput=cat(f,`.eps`),plotoptions=`noborder`); print(display(p));
  plotsetup(default,plotoptions=`noborder`): print(display(p));
end:

pr:=proc(x) print(x); x; end:

grad:=(F,V)->map(q->diff(F,q),V):

linsplit:=(F,V)->subs(map(q->q=0,V),[op(grad(F,V)),F]):

corr:=proc(x,y) local i; seq(x[i]=y[i],i=1..nops(x)): end:

ssum:=(F,V)->convert([seq(F,V)],`+`):

pprod:=(F,V)->convert([seq(F,V)],`*`):

Lag:=proc(t,tx,kx) local i,j;
  ssum(kx[i]*pprod(piecewise(j=i,1,(t-tx[j])/(tx[i]-tx[j])),j=1..nops(tx)),i=1..nops(tx)):
end:

Lag(t,[ta,tb],[a,b]); Lag(t,[ta,tb,tc],[a,b,c]);

pi:=evalf(Pi);

gM:=evalf(solve((1-x)^2=x,x)[2]):
goldMin:=proc(f,T,epsilon) local a,b,c,d,fa,fb,fc,fd,k;
  a:=op(1,T); b:=op(2,T); fa:=f(a); fb:=f(b); k:=0;
  c:=a+(b-a)*gM; fc:=f(c); d:=b-(b-a)*gM; fd:=f(d);
  while abs(a-b)>epsilon do: k:=k+1;
    if fc>fd then a:=c; fa:=fc; c:=d; fc:=fd; d:=b-(b-a)*gM; fd:=f(d);

```

```

else b:=d; fb:=fd; d:=c; fd:=fc;+ c:=a+(b-a)*gM; fc:=f(c);
fi;
od: #print(k);
(a+b)/2;
end:

findMin1:=proc(F,V) local f,df,f0,f1,f2,V0,V1,V2,ff,t,dt,i,j;
ff:=V->F(op(evalf(map(exp,V)))); V1:=evalf(map(ln,V)); f1:=F(op(V));
f:=[seq(F(seq(evalf(exp(V1[j]+piecewise(j=i,0.0001,0))),j=1..nops(V))),i=1..nops(V))];
df:=[seq((f[j]-f1)/0.1,j=1..nops(V))];
V0:=V1-0.001*df; f0:=ff(V0); V2:=V1+0.001*df; f2:=ff(V2);
dt:=0.0001; while f0<f1 do: V2:=V1; f2:=f1; V1:=V0; f1:=f0; V0:=V0-dt*df; f0:=ff(V0); dt:=dt*
1.5; od;
dt:=0.0001; while f2<f1 do: V0:=V1; f0:=f1; V1:=V2; f1:=f2; V2:=V2+dt*df; f2:=ff(V2); dt:=dt*
1.5; od;
t:=goldMin(t->ff(t*V0+(1-t)*V2),0..1,0.001);
map(exp,t*V0+(1-t)*V2);
end:

findMin:=proc(F,V) local V1,Z1,Z2;
Z2:=pr(F(op(V))); V1:=findMin1(F,V); Z1:=pr(chi2(op(V1)));
while abs(1-Z1/Z2)>0.0001 do; Z2:=Z1; V1:=findMin1(F,V1); Z1:=pr(chi2(op(V1))); end;
V1;
end:

```

$$\frac{a(t-tb)}{ta-tb} + \frac{b(t-ta)}{tb-ta}$$

$$\frac{a(t-tb)(t-tc)}{(ta-tb)(ta-tc)} + \frac{b(t-ta)(t-tc)}{(tb-ta)(tb-tc)} + \frac{c(t-ta)(t-tb)}{(tc-ta)(tc-tb)}$$

$$\pi := 3.141592654$$

(1)

```
> Region:="Russia";
```

```
Region := "Russia"
```

(2)

```
> val:=proc() global data,i; local j;
while not(data[i] in {"0","1","2","3","4","5","6","7","8","9","0"}) do i:=i+1: od:
j:=i; while (data[i] in {"0","1","2","3","4","5","6","7","8","9","0"}) do i:=i+1: od: parse(data
[j..i-1]);
```

```

end:

read `xxx.txt`: data:=convert(X,string): data[1..300];

SSearch:=(i,f,d)->Search(f,d[i..Length(d)])+i-1:

i:=Search(Region,data): data[i-5..i+20]: i:=SSearch(i,"statistics",data)+12; i:=SSearch(i,"date",
data)+7; data[i..i+300];
val(); val(); val(); dd:=%-1+piecewise(%%=2,-29,%%=4,31,0);

i:=Search(Region,data): data[i-5..i+20]: i:=SSearch(i,"statistics",data)+12: data[i..i+300]:
j:=SSearch(i,"",data): StringTools:-Map(q->piecewise(q="","",q="{","[" ,q="}",""]",q),data[i..j]
):
%[1..100]: TT:=parse(%%): #Matrix(%);

i:='i': j:='j':

T:=map(q->q[2],TT): #writedata(cat(Region,"-i.txt"),%):
T1:=map(q->q[4],TT): #writedata(cat(Region,"-r.txt"),%):
T3:=map(q->q[6],TT): #writedata(cat(Region,"-m.txt"),%):

T2:=map(q->q[2]-q[4]-q[6],TT): #writedata(cat(Region,"-h.txt"),%):

Region; 'T'=T; 'T1'=T1; 'T2'=T2; 'T3'=T3;

nops(T); [seq(i+dd,i=1..%)];

```

```

>window.dataFromServer = {"cities":{"data":{"cities":[{"coordinates":[36.952915,-99.115868],"confirmed":2356783,"deaths":122250,
"cured":980367,"commentsCount":4105,"isCountry":true,"en":"USA","ru":"","statistics":[{"confirmed":102605,"cured":2297,
"deaths":1374,"date":"2020-03-27T00:00:00.000Z"}]}

```

```

i := 2063450

```

```

i := 2063495

```

```

"2020-03-02T00:00:00.000Z"}, {"confirmed":7,"cured":4,"deaths":0,"date":"2020-03-03T00:00:00.000Z"}, {"confirmed":7,"cured":4,
"deaths":0,"date":"2020-03-04T00:00:00.000Z"}, {"confirmed":11,"cured":4,"deaths":0,"date":"2020-03-05T00:00:00.000Z"},
{"confirmed":11,"cured":4,"deaths":0,"date":"2020-03-06T00:00:00.000Z"}]

```

```

2020

```



112, 113, 114]

```
> `=====`;  
`VERHULST FITAING`;  
`=====`;
```

=====

*VERHULST FITAING*

=====

(4)

```
> h:=x->x;
```

```
[seq(h(T[i])-h(T[i-1]),i=2..nops(T)); [seq(%[i]-%[i-1],i=2..nops(%))]; [seq(%[i]-%[i-1],i=2..nops(%))];  
[seq([i+dd+1,%%[i]],i=1..nops(%%))]: [seq([i+dd+2,%%[i]],i=1..nops(%%))]: [seq([i+dd+3,%%[i]],i=1..nops(%%))]:  
display(  
  plot([%%,%,%],style=point),  
  plot([%%,%,%],legend=[``,``,``]),  
  title=`  N[i]`,titlefont=[roman,15],gridlines=true  
);
```

```
[seq((h(T[i])-h(T[i-5]))/5.,i=6..nops(T)): [seq((%[i]-%[i-3])/3.,i=4..nops(%)): [seq((%[i]-%[i-3])/3.,i=4..nops(%))]:  
[seq([i+dd+2,%%[i]],i=1..nops(%%))]: [seq([i+dd+4,%%[i]],i=1..nops(%%))]: [seq([i+dd+6,%%[i]],i=1..nops(%%))]:  
display(  
  plot([%%,%,%],style=point),  
  plot([%%,%,%],legend=[``,``,``]),  
  title=`  N [ i ]`,titlefont=[roman,15],gridlines=true  
);
```

$h := x \mapsto x$

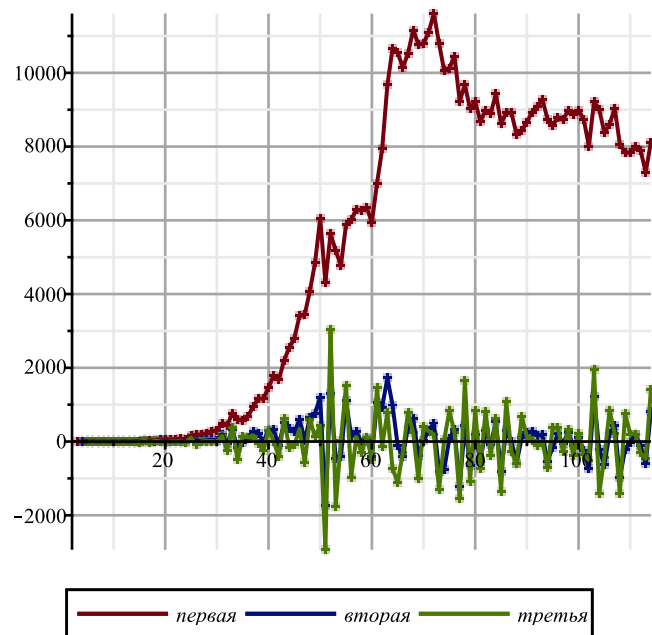
[0, 0, 4, 0, 3, 0, 3, 3, 8, 6, 11, 14, 4, 30, 21, 33, 52, 52, 55, 61, 71, 65, 163, 179, 195, 225, 269, 306, 497, 443, 768, 602, 584, 676, 941, 1166, 1161, 1467, 1784, 1683, 2194, 2546, 2808, 3407, 3438, 4079, 4848, 6051, 4319, 5635, 5182, 4767, 5880, 6022, 6291, 6257, 6342, 5945, 7008, 7942, 9671, 10662, 10546, 10142, 10533, 11161, 10775, 10799, 11104, 11607, 10805, 10052, 10130, 10453, 9231, 9674, 9027, 9216, 8684, 8979, 8892, 9431, 8627, 8914, 8923, 8334, 8431, 8663, 8930, 9097, 9275, 8744, 8582, 8790, 8729, 8986, 8867, 8979, 8745, 8008, 9216, 9008, 8380, 8600, 9041, 8062, 7844, 7829, 8015, 7896, 7307, 8119]

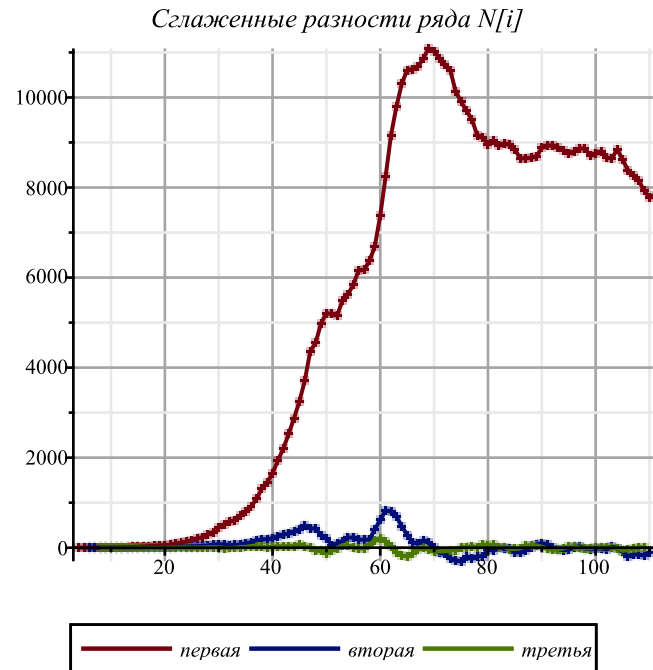
[0, 4, -4, 3, -3, 3, 0, 5, -2, 5, 3, -10, 26, -9, 12, 19, 0, 3, 6, 10, -6, 98, 16, 16, 30, 44, 37, 191, -54, 325, -166, -18, 92, 265, 225, -5,

306, 317, -101, 511, 352, 262, 599, 31, 641, 769, 1203, -1732, 1316, -453, -415, 1113, 142, 269, -34, 85, -397, 1063, 934, 1729, 991, -116, -404, 391, 628, -386, 24, 305, 503, -802, -753, 78, 323, -1222, 443, -647, 189, -532, 295, -87, 539, -804, 287, 9, -589, 97, 232, 267, 167, 178, -531, -162, 208, -61, 257, -119, 112, -234, -737, 1208, -208, -628, 220, 441, -979, -218, -15, 186, -119, -589, 812]

[4, -8, 7, -6, 6, -3, 5, -7, 7, -2, -13, 36, -35, 21, 7, -19, 3, 3, 4, -16, 104, -82, 0, 14, 14, -7, 154, -245, 379, -491, 148, 110, 173, -40, -230, 311, 11, -418, 612, -159, -90, 337, -568, 610, 128, 434, -2935, 3048, -1769, 38, 1528, -971, 127, -303, 119, -482, 1460, -129, 795, -738, -1107, -288, 795, 237, -1014, 410, 281, 198, -1305, 49, 831, 245, -1545, 1665, -1090, 836, -721, 827, -382, 626, -1343, 1091, -278, -598, 686, 135, 35, -100, 11, -709, 369, 370, -269, 318, -376, 231, -346, -503, 1945, -1416, -420, 848, 221, -1420, 761, 203, 201, -305, -470, 1401]

Разности ряда  $N[i]$





```
> h:=x->evalf(ln(x));
```

```
[seq(h(T[i])-h(T[i-1]),i=2..nops(T)); [seq(%[i]-%[i-1],i=2..nops(%))]; [seq(%[i]-%[i-1],i=2..nops(%))];
[seq([i+dd+1,%%[i]],i=1..nops(%%))]: [seq([i+dd+2,%%[i]],i=1..nops(%%))]: [seq([i+dd+3,%%[i]],i=1..nops(%%))]:
display(
  plot([%%,%,%],style=point),
  plot([%%,%,%],legend=[``,``,``]),
  title=`ln(N[i])`,titlefont=[roman,15],gridlines=true
);
```

```
[seq((h(T[i])-h(T[i-5]))/5.,i=6..nops(T)): [seq((%[i]-%[i-3])/3.,i=4..nops(%)): [seq((%[i]-%[i-3])/3.,i=4..nops(%))]:
[seq([i+dd+2,%%[i]],i=1..nops(%%))]: [seq([i+dd+4,%%[i]],i=1..nops(%%))]: [seq([i+dd+6,%%[i]],i=1..nops(%%))]:
display(
  plot([%%,%,%],style=point),
  plot([%%,%,%],legend=[``,``,``]),
```

```
title = `ln(N[i])`, titlefont=[roman,15], gridlines=true);
```

$h := x \mapsto \text{evalf}(\ln(x))$

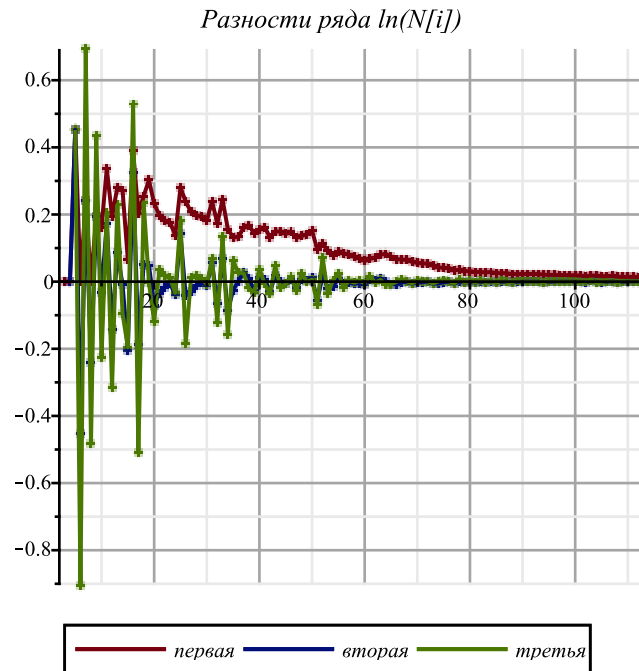
```
[0., 0., 0.451985124, 0., 0.241162057, 0., 0.194156014, 0.162518930, 0.336472236, 0.194156015, 0.280301965, 0.270874954, 0.065597282, 0.389464767, 0.203598955, 0.254234139, 0.302872238, 0.232148114, 0.198132163, 0.181776746, 0.176857062, 0.138371260, 0.280699501, 0.238046956, 0.207639365, 0.195851409, 0.192806581, 0.181886869, 0.239102484, 0.173582872, 0.243933136, 0.156724270, 0.131662177, 0.133478582, 0.160363188, 0.168554841, 0.143623965, 0.156189886, 0.161991437, 0.131979347, 0.149437858, 0.149348945, 0.142374047, 0.149291474, 0.13097898, 0.13597440, 0.14072092, 0.15172631, 0.09574789, 0.11254995, 0.09339010, 0.07883093, 0.08938588, 0.08394800, 0.08076655, 0.07433876, 0.07010062, 0.06152969, 0.06798122, 0.07183789, 0.08103520, 0.08233087, 0.07526789, 0.06740392, 0.06550251, 0.06502297, 0.05900148, 0.05583411, 0.05433449, 0.05380650, 0.04761325, 0.04234765, 0.04093583, 0.04055462, 0.03449526, 0.03491753, 0.03151799, 0.03118476, 0.02852053, 0.02865824, 0.02759352, 0.02845727, 0.02534057, 0.02552604, 0.02491546, 0.02272317, 0.02247400, 0.02257805, 0.02275234, 0.02265752, 0.02258416, 0.02083404, 0.02003447, 0.02011224, 0.01958021, 0.01976404, 0.01912675, 0.01900261, 0.01816662, 0.01635100, 0.01849247, 0.01775054, 0.01623484, 0.01639147, 0.01694713, 0.01487352, 0.01426206, 0.01403481, 0.01416706, 0.01376317, 0.01256993, 0.01378393]
```

```
[0., 0.451985124, -0.451985124, 0.241162057, -0.241162057, 0.194156014, -0.031637084, 0.173953306, -0.142316221, 0.086145950, -0.009427011, -0.205277672, 0.323867485, -0.185865812, 0.050635184, 0.048638099, -0.070724124, -0.034015951, -0.016355417, -0.004919684, -0.038485802, 0.142328241, -0.042652545, -0.030407591, -0.011787956, -0.003044828, -0.010919712, 0.057215615, -0.065519612, 0.070350264, -0.087208866, -0.025062093, 0.001816405, 0.026884606, 0.008191653, -0.024930876, 0.012565921, 0.005801551, -0.030012090, 0.017458511, -0.000088913, -0.006974898, 0.006917427, -0.018312494, 0.00499542, 0.00474652, 0.01100539, -0.05597842, 0.01680206, -0.01915985, -0.01455917, 0.01055495, -0.00543788, -0.00318145, -0.00642779, -0.00423814, -0.00857093, 0.00645153, 0.00385667, 0.00919731, 0.00129567, -0.00706298, -0.00786397, -0.00190141, -0.00047954, -0.00602149, -0.00316737, -0.00149962, -0.00052799, -0.00619325, -0.00526560, -0.00141182, -0.00038121, -0.00605936, 0.00042227, -0.00339954, -0.00033323, -0.00266423, 0.00013771, -0.00106472, 0.00086375, -0.00311670, 0.00018547, -0.00061058, -0.00219229, -0.00024917, 0.00010405, 0.00017429, -0.00009482, -0.00007336, -0.00175012, -0.00079957, 0.00007777, -0.00053203, 0.00018383, -0.00063729, -0.00012414, -0.00083599, -0.00181562, 0.00214147, -0.00074193, -0.00151570, 0.00015663, 0.00055566, -0.00207361, -0.00061146, -0.00022725, 0.00013225, -0.00040389, -0.00119324, 0.00121400]
```

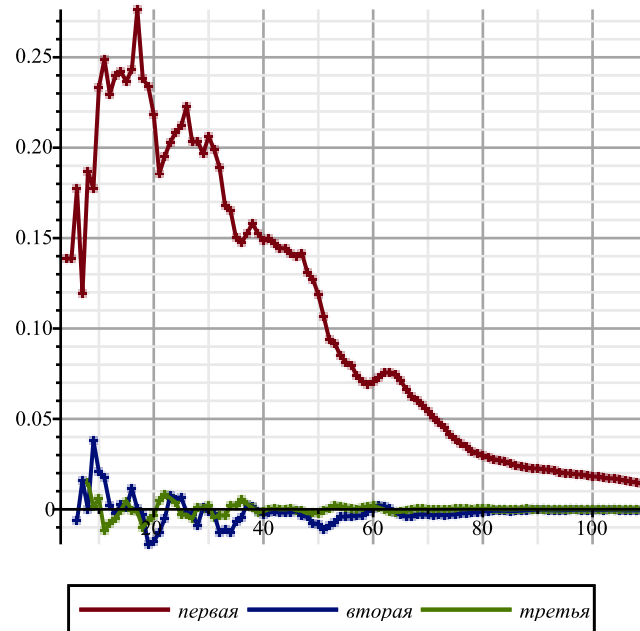
```
[0.451985124, -0.903970248, 0.693147181, -0.482324114, 0.435318071, -0.225793098, 0.205590390, -0.316269527, 0.228462171, -0.095572961, -0.195850661, 0.529145157, -0.509733297, 0.236500996, -0.001997085, -0.119362223, 0.036708173,
```



0.017660534, 0.011435733, -0.033566118, 0.180814043, -0.184980786, 0.012244954, 0.018619635, 0.008743128, -0.007874884, 0.068135327, -0.122735227, 0.135869876, -0.157559130, 0.062146773, 0.026878498, 0.025068201, -0.018692953, -0.033122529, 0.037496797, -0.006764370, -0.035813641, 0.047470601, -0.017547424, -0.006885985, 0.013892325, -0.025229921, 0.023307914, -0.00024890, 0.00625887, -0.06698381, 0.07278048, -0.03596191, 0.00460068, 0.02511412, -0.01599283, 0.00225643, -0.00324634, 0.00218965, -0.00433279, 0.01502246, -0.00259486, 0.00534064, -0.00790164, -0.00835865, -0.00080099, 0.00596256, 0.00142187, -0.00554195, 0.00285412, 0.00166775, 0.00097163, -0.00566526, 0.00092765, 0.00385378, 0.00103061, -0.00567815, 0.00648163, -0.00382181, 0.00306631, -0.00233100, 0.00280194, -0.00120243, 0.00192847, -0.00398045, 0.00330217, -0.00079605, -0.00158171, 0.00194312, 0.00035322, 0.00007024, -0.00026911, 0.00002146, -0.00167676, 0.00095055, 0.00087734, -0.00060980, 0.00071586, -0.00082112, 0.00051315, -0.00071185, -0.00097963, 0.00395709, -0.00288340, -0.00077377, 0.00167233, 0.00039903, -0.00262927, 0.00146215, 0.00038421, 0.00035950, -0.00053614, -0.00078935, 0.00240724]



Сглаженные разности ряда  $\ln(N[i])$



```

> f_:=d->sum(a[j]*d^j,j=0..n); fe_:=d->sum(a[j]*d^j,j=0..ne);

M:='M':
ff:=x->M*(1-1/(exp(x)+1)); ff_:=unapply(solve(y=ff(x),x),y); diff(ff_(x),x); dff_:=unapply
(simplify(% ,x),x);
ffe:=x->exp(x); ffe_:=unapply(solve(y=ffe(x),x),y); diff(ff_(x),x); dffe_:=unapply(simplify(% ,
x),x);

sigma:=x->simplify(sqrt(x));

chi2:=(T,f_)->simplify(sum(evalf(ff_(T[k])-f_(k))^2/dff_(T[k])^2/sigma(T[k])^2,k=1..nops(T)));
chi2e:=(T,f_)->simplify(sum(evalf(ff_(T[k])-f_(k))^2/dffe_(T[k])^2/sigma(T[k])^2,k=1..nops(T)));

F:=proc(T,chi2,f_) chi2(T,f_);
  indets(%); grad(% ,%); subs(solve(% ,%),f_(i)); unapply(% ,i);
end:

```

$$f_ := d \mapsto \sum_{j=0}^n a_j \cdot d^j$$

$$\begin{aligned}
fe_- &:= d \mapsto \sum_{j=0}^{ne} a_j \cdot d^j \\
ff &:= x \mapsto M \cdot \left( 1 - \frac{1}{e^x + 1} \right) \\
ff_- &:= y \mapsto \ln \left( \frac{y}{M-y} \right) \\
&\frac{\left( \frac{1}{M-x} + \frac{x}{(M-x)^2} \right) (M-x)}{x} \\
dff_- &:= x \mapsto \frac{M}{(M-x) \cdot x} \\
ffe &:= x \mapsto e^x \\
ffe_- &:= y \mapsto \ln(y) \\
&\frac{1}{x} \\
dff_- &:= x \mapsto \frac{1}{x} \\
\sigma &:= x \mapsto \text{simplify}(\sqrt{x}) \\
\chi^2 &:= (T, f_-) \rightarrow \text{simplify} \left( \sum_{k=1}^{nops(T)} \frac{\text{evalf}(ff_-(T_k) - f_-(k))^2}{dff_-(T_k)^2 \sigma(T_k)^2} \right) \\
\chi^2_e &:= (T, f_-) \rightarrow \text{simplify} \left( \sum_{k=1}^{nops(T)} \frac{\text{evalf}(ffe_-(T_k) - f_-(k))^2}{dff_-(T_k)^2 \sigma(T_k)^2} \right)
\end{aligned}$$

(5)

```
> n:=1: ne:=n: 'f(t)'=Sum(a[j]*t^j,j=0..n);
```

```
fM:=proc(x) global M,chi2,F,T,f_; M:=x; chi2(T,F(T,chi2,f_)); end:
```

```
` `; `Approximation of the infection schedule by the solution of the Verhulst equation`; ` `;
M:=goldMin(fM,max(T)+2..max(T)*2,1);
```

```

nu:=F(T,chi2,f_): f:=unapply(ff(%(t)),t): N(t)=%(t); Chi2:=chi2(T,%%);
cat(`Next day forecast:`,round(f(nops(T)+1)));
cat(`The level of 0.5 M is reached at`,round(1+fsolve(f(d)=0.5*M,d=30)+dd-31),` apr`);
cat(`The level of 0.85 M is reached at`,round(1+fsolve(f(d)=0.85*M,d=30)+dd-31),` apr`);
``; `Approximation of the infection schedule by solving the Malthus equation`; ``;
nue:=F(T,chi2e,f_): fe:=unapply(ff(%(t)),t): N(t)=%(t);

simplify([diff(nu(d-dd),d),diff(nue(d-dd),d)]): [coeff(%[1],d,i) $ i=0..n-1];
plot(%%,d=1+dd..nops(T)+dd,view=[0..nops(T)+dd,0..0.5],legend=[``,``],
linestyle=[solid,dash],title=`,titlefont=[roman,20],labels=[t,alpha(t)],
gridlines=true);

d1:=fsolve(f(d)=0.5*M,d=30)+dd; K_:=M; alpha_:=coeff(nu(t),t,1);

n:=4: ne:=n: 'f(t)'=Sum(a[j]*t^j,j=0..n);

fM:=proc(x) global M,chi2,F,T,f_; M:=x; chi2(T,F(T,chi2,f_)); end:

``; `Approximation of the infection schedule by the solution of the Verhulst equation`; ``;
M:=goldMin(fM,max(T)+2..max(T)*2,1);
nu:=F(T,chi2,f_): f:=unapply(ff(%(t)),t): N(t)=%(t); Chi2:=chi2(T,%%);
cat(`Next day forecast:`,round(f(nops(T)+1)));
cat(`The level of 0.5 M is reached at`,round(1+fsolve(f(d)=0.5*M,d=30)+dd-31),` apr`);
cat(`The level of 0.85 M is reached at`,round(1+fsolve(f(d)=0.85*M,d=30)+dd-31),` apr`);
``; `Approximation of the infection schedule by solving the Malthus equation`; ``;
nue:=F(T,chi2e,f_): fe:=unapply(ff(%(t)),t): N(t)=%(t);

[seq([i,(
(T[i-dd]-T[i-dd-1])/(T2[i-dd]+T2[i-dd-1])/((1-T[i-dd]/M)+(1-T[i-dd-1]/M))
)*4],i=1+dd+1..nops(T)+dd)]: [seq( [%[i][1],(%[i-1][2]+[%i][2]+[%i+1][2])/3],i=2..nops(%) -1)]:
Palpha:=display(plot( [%],color=blue),plot( [%],style=point,symbolsize=8,symbol=solidcircle,color=
blue));

simplify([diff(nu(d-dd),d),diff(nue(d-dd),d)]): [coeff(%[1],d,i) $ i=0..n-1];
plot(%%,d=1+dd..nops(T)+dd,view=[0..nops(T)+dd,0..0.5],legend=[``,``],
linestyle=[solid,dash],title=`,titlefont=[roman,20],labels=[t,alpha(t)],
gridlines=true);

display(Palpha,%);

```

$$f(t) = \sum_{j=0}^1 a_j t^j$$

*Approximation of the infection schedule by the solution of the Verhulst equation*

$$M := 593090.4173$$

$$N(t) = 593090.4173 - \frac{593090.4173}{e^{0.08458390964t - 6.689103810} + 1}$$

$$Chi2 := 176090.0409$$

*Next day forecast: 563689*

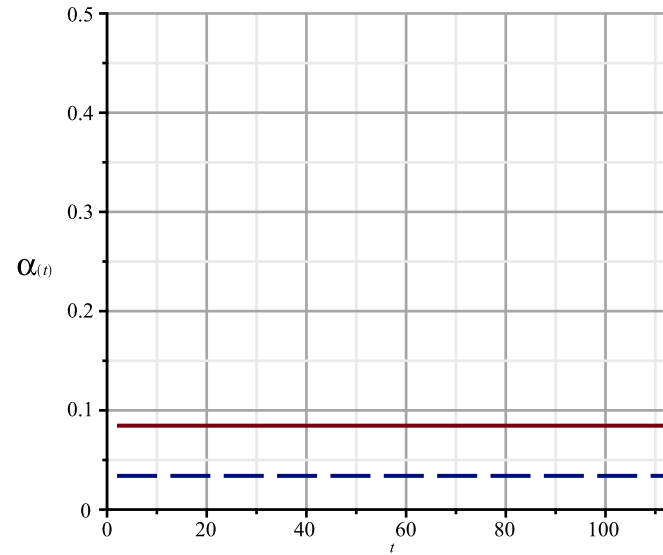
*The level of 0.5 M is reached at 50 apr*

*The level of 0.85 M is reached at 71 apr*

*Approximation of the infection schedule by solving the Malthus equation*

$$N(t) = e^{0.03399469856t + 9.696837036} [0.08458390964]$$

*Коэффициент заражения*



— Ферхюльст    - - - Мальтус

$$dI := 80.08246188$$

$$K_ := 593090.4173$$

$$alpha_ := 0.08458390964$$

$$f(t) = \sum_{j=0}^4 a_j t^j$$

*Approximation of the infection schedule by the solution of the Verhulst equation*

$$M := 763106.5664$$

$$N(t) = 763106.5664 - \frac{763106.5664}{e^{3.744254469 \cdot 10^{-8} t^4 + 1.161960726 \cdot 10^{-6} t^3 - 0.002261125556 t^2 + 0.3153458516 t - 13.27484265} + 1}$$

$$Chi2 := 3217.029876$$

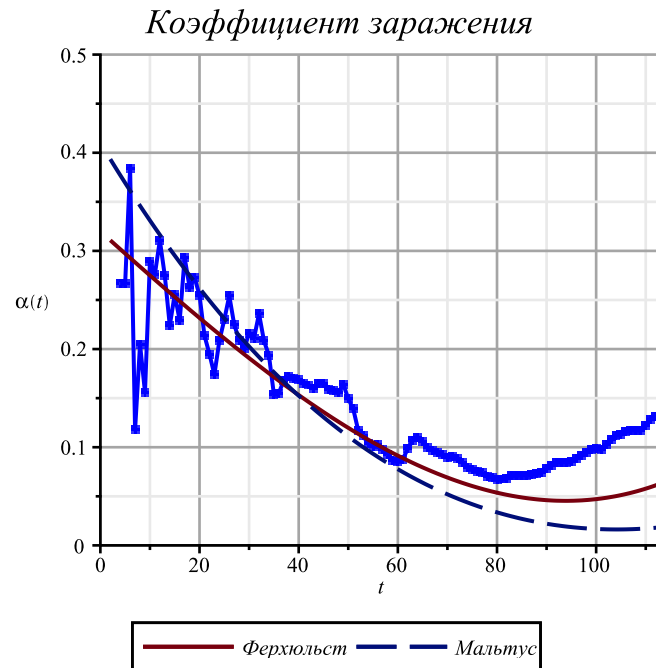
*Next day forecast: 604049*

The level of 0.5 M is reached at 59 apr  
 The level of 0.85 M is reached at 90 apr

Approximation of the infection schedule by solving the Malthus equation

$$N(t) = e^{-2.004561636 \cdot 10^{-8} t^4 + 0.00001759510790 t^3 - 0.004164508705 t^2 + 0.4017496286 t - 1.032770898}$$

$$[0.319871438800000, -0.00452877356500000, 3.03657164200000 \cdot 10^{-6}, 1.497701788 \cdot 10^{-7}]$$



```
> df:=unapply(diff(f(i),i),i): ddf:=unapply(diff(f(i),i,i),i):
```

```
display(
  plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=10,symbol=solidcircle),
  plot(fe(i-dd),i=1+dd..max(90,dd+nops(T)),color=magenta),
  plot(f(i-dd),i=1+dd..max(90,dd+nops(T))),
  seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
  axis[2]=[mode=log],
  view=[1..80,1..M*1.1],labels=[t,N(t)],gridlines=true
```

```

);

display(
  plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=8,symbol=solidcircle),
  plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
  plot(f(i-dd),i=1+dd..max(120,dd+nops(T))),
  # seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
  axis[2]=[mode=log],
  view=[1..nops(T)+dd+1,1..T[nops(T)]*1.1],labels=[t,N(t)],gridlines=true
);

```

```

display(
  plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=10,symbol=solidcircle),
  plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
  plot(f(i-dd),i=1+dd..max(dd+nops(T),90)),
  plot(10*df(i-dd),i=1+dd..max(dd+nops(T),120),color=black),
  plot(100*ddf(i-dd),i=1+dd..max(dd+nops(T),120),color=gray),
  seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
  view=[1..80,-M*0.3..M*1.1],labels=[t,N(t)],gridlines=true
);

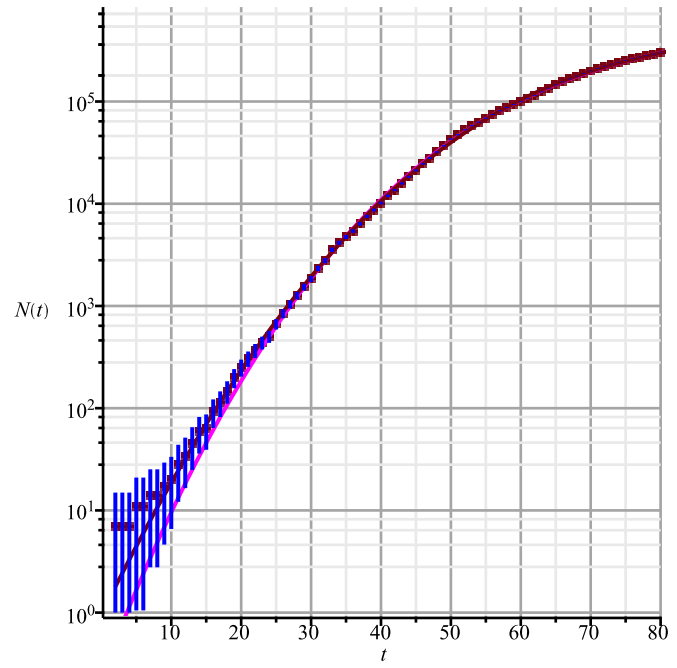
```

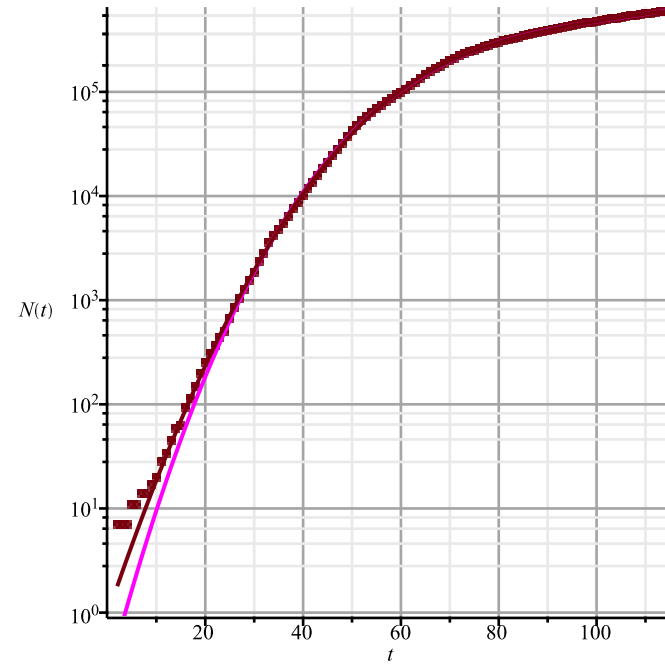
```

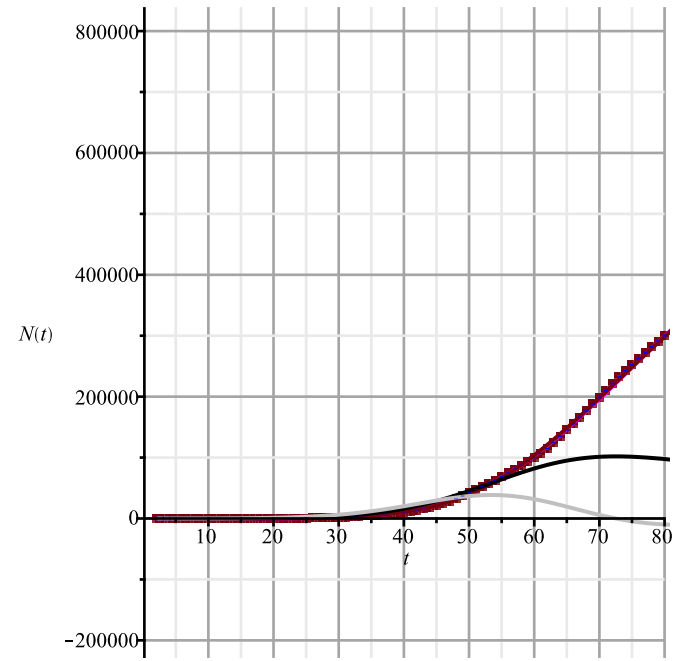
display(
  plot([[i+dd,T[i]] $ i=1..nops(T)],style=point,symbolsize=8,symbol=solidcircle),
  plot(fe(i-dd),i=1+dd..max(120,dd+nops(T)),color=magenta),
  plot(f(i-dd),i=1+dd..max(dd+nops(T),120)),
  # seq(plot([[i+dd,T[i]+3*sqrt(T[i])],[i+dd,T[i]-3*sqrt(T[i])]],color=blue),i=1..nops(T)),
  view=[1..nops(T)+dd+1,1..T[nops(T)]*1.1],labels=[t,N(t)],gridlines=true
);

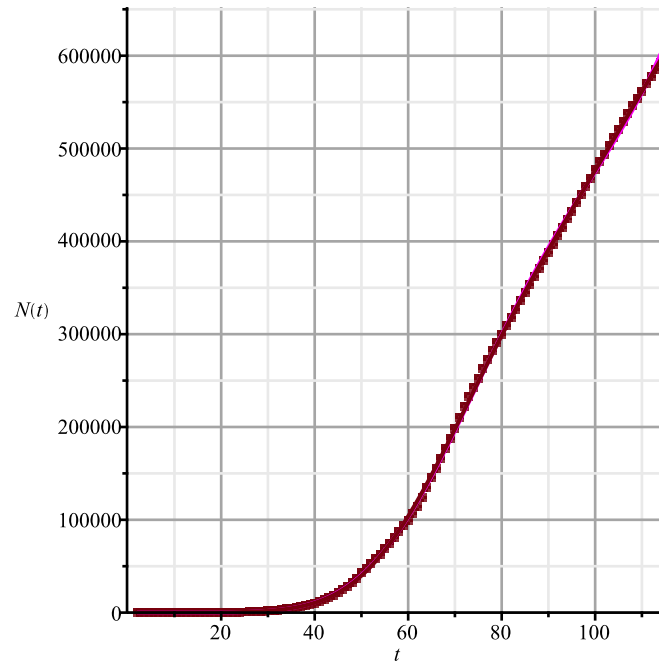
```



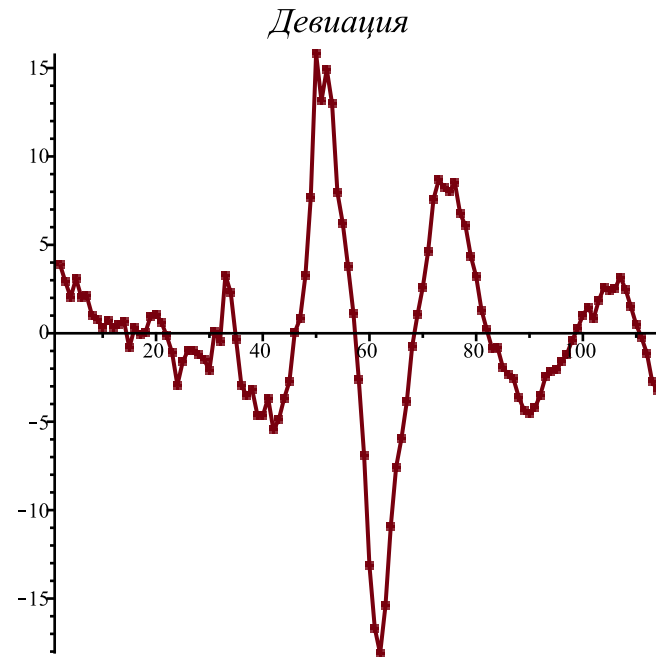








```
> dT:=[[i, (T[i-dd]-f(i-dd))/sigma(f(i-dd))] $ i=1+dd..dd+nops(T)]:
display( plot(%), plot(% ,style=point,symbolsize=8,symbol=solidcircle),title = ` ` ,titlefont=
[roman,20] );
```



```

> ===== ` ;
`FORECAST` ;
===== ` ;

=====
FORECAST
=====

> proc3:=proc (E)
  E[1]*convert (map (X->X^coeff (E[2] ,X,1) ,M) , `*` ) ;
end:

proc2:=proc (X,E)
  proc3 (E) * (coeff (E[3] ,X,1) -coeff (E[2] ,X,1)) ;
end:

proc1:=proc (X)
  convert (map (E->proc2 (X,E) ,L) , `+` ) ;
end:

```

```
> A:='A': B:='B': C:='C': Q:='Q': M:=[A,B,C,Q];
```

```
L:=
  [(A+C)*P[`01`],0,A],
  [(B/K)*P[`12`],A,B],
  [P[`23`],B,C],
  [P[`10`],A,0], [P[`20`],B,Q], [P[`30`],C,0]
]: Matrix(%);
```

```
eqs:=map(X->Diff(X,t)=procl(X),M); Vector(%);
```

$M := [A, B, C, Q]$

$$\begin{bmatrix} (A+C)P_{01} & 0 & A \\ \frac{BP_{12}}{K} & A & B \\ P_{23} & B & C \\ P_{10} & A & 0 \\ P_{20} & B & Q \\ P_{30} & C & 0 \end{bmatrix}$$

$$eqs := \left[ \frac{\partial}{\partial t} A = (A+C)P_{01} - \frac{BP_{12}A}{K} - P_{10}A, \frac{\partial}{\partial t} B = \frac{BP_{12}A}{K} - P_{23}B - P_{20}B, \frac{\partial}{\partial t} C = P_{23}B - P_{30}C, \frac{\partial}{\partial t} Q = P_{20}B \right]$$

$$\begin{cases} \frac{\partial}{\partial t} A = (A + C) P_{01} - \frac{B P_{12} A}{K} - P_{10} A \\ \frac{\partial}{\partial t} B = \frac{B P_{12} A}{K} - P_{23} B - P_{20} B \\ \frac{\partial}{\partial t} C = P_{23} B - P_{30} C \\ \frac{\partial}{\partial t} Q = P_{20} B \end{cases}$$

(7)

```
> v:=M; alpha:='alpha': K:=k0; tA:=[-7,15,35,50,58,62,78,nops(T)+dd]; kA:=['k1x||i' $ i=1..nops(tA)
];
```

```
par:=[d0,k0,op(kA),k2a,k2b,k2c,k3]; kappa:=0; 0.011/365;
```

```
param:=[
  P[`01`] = kappa, P[`12`] = alpha(t,op(kA)), P[`23`] = beta(t,k2a,k2b,k2c),
  P[`10`] = kappa, P[`20`] = k3, P[`30`] = kappa
];
```

```
init:=[ A(-d0)=K, B(-d0)=1, C(-d0)=0, Q(-d0)=0 ];
```

$$v := [A, B, C, Q]$$

$$K := k0$$

$$tA := [-7, 15, 35, 50, 58, 62, 78, 114]$$

$$kA := [k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8]$$

$$par := [d0, k0, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8, k2a, k2b, k2c, k3]$$

$$\kappa := 0$$

$$0.00003013698630$$

$$param := [P_{01} = 0, P_{12} = \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8), P_{23} = \beta(t, k2a, k2b, k2c), P_{10} = 0, P_{20} = k3, P_{30} = 0]$$

$$init := [A(-d0) = k0, B(-d0) = 1, C(-d0) = 0, Q(-d0) = 0]$$

(8)

```
> Eqs:=subs(map(q->q=q(t),v),Diff=diff,param,eqs); #dsolve(%);
```

$$Eqs := \left[ \frac{d}{dt} A(t) = - \frac{B(t) \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8) A(t)}{k0}, \frac{d}{dt} B(t) \right.$$

$$= \frac{B(t) \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8) A(t)}{k0} - \beta(t, k2a, k2b, k2c) B(t) - k3 B(t), \frac{d}{dt} C(t) = \beta(t, k2a, k2b,$$

$$k2c) B(t), \left. \frac{d}{dt} Q(t) = k3 B(t) \right]$$

```
> N:='N': A:='A': B:='B': C:='C': Q:='Q':
```

```
val:=readdata(cat(Region,"3b.txt"));
```

```
#alpha:=unapply(simplify(evalf(piecewise(t<tA[1],kA[1],t<tA[2],Lag(t,tA[1..3],kA[1..3]),
# seq(op([t<tA[i+1],(Lag(t,tA[i-1..i+1],kA[i-1..i+1])+Lag(t,tA[i..i+2],kA[i..i+2]))/2]),i=2..nops
(kA)-2),
#t<tA[nops(tA)],Lag(t,tA[nops(tA)-2..nops(tA)],kA[nops(kA)-2..nops(kA)]),
#kA[nops(kA)])),t,op(kA)){
```

```
alpha:=unapply(simplify(evalf(piecewise(t<tA[1],kA[1],t<tA[3],Lag(t,tA[1..4],kA[1..4]),
seq(op([t<tA[i+1],Lag(t,tA[i-1..i+2],kA[i-1..i+2])]),i=3..nops(kA)-2),
t<tA[nops(tA)],Lag(t,tA[nops(tA)-2..nops(tA)],kA[nops(kA)-2..nops(kA)]),
kA[nops(kA)]))),t,op(kA)):
```

```
beta:=(t,k2a,k2b,k2c)->piecewise(t<55,Lag(t,[20,55],[k2a,k2b]),t<90,Lag(t,[55,90],[k2b,k2c]),k2c)
:
```

```
beta:=unapply(simplify(evalf(beta(t,k2a,k2b,k2c))),t,k2a,k2b,k2c);
```

```
EQS:=[op(Eqs),op(init)]:
```

```
res:=dsolve(EQS,numeric,map(q->q(t),v),output=listprocedure,parameters=par); assign('v[i]=subs
(res,v[i](t))' $ i=1..nops(v)):
```

```
chi2a:='chi2a': chi2:=unapply(chi2a(x0,xx,kA,x2a,x2b,x2c,x3),x0,xx,op(kA),x2a,x2b,x2c,x3):
```

```
chi2a:=proc(x0,xx,x1,x2a,x2b,x2c,x3) local i; global K; K:=xx;
res(parameters=[corr(par,[x0,xx,op(x1),x2a,x2b,x2c,x3])]):
sum((T[i]-K-A(i+dd))^2/(K-A(i+dd)),i=1..nops(T))+
sum((T2[i]-B(i+dd))^2/B(i+dd),i=1..nops(T2))+
sum((T3[i]-Q(i+dd))^2/Q(i+dd),i=1..nops(T2))+
```



```

    sum((T1[i]-C(i+dd))^2/C(i+dd),i=1..nops(T1));
end:

chi2(op(pr(val))); val:=findMin(chi2,val); chi2(op(%));

#plot(map(q->q(t),v), t = 0 .. 3.0e4, legend = [ ` ` , ` ` , ` ` ] ,
#linestyle=[solid,dash,dashdot],gridlines=true);

writedata(cat(Region,"3b.txt"),val);

display(
  plot(map(q->q(t),v[1..3]), t = 0 .. 300, legend = [ ` ` , ` ` , ` ` ] ,
    linestyle=[solid,dash,dashdot],gridlines=true),
  plot([[seq([i+dd,K_-T[i]],i=1..nops(T))]],style=point,symbolsize=7,symbol=asterisk),
  plot([[seq([i+dd,T1[i]],i=1..nops(T1))]],style=point,symbolsize=7,symbol=circle),
  plot([[seq([i+dd,T2[i]],i=1..nops(T2))]],style=point,symbolsize=7,symbol=diamond,color=black),
  size=[1000,400],labelfont=[roman,15],legendstyle=[font=[roman,15]]
): fdisplay(cat(Region,"3b"),%);

```

```

val := [17.41497486, 612241.5749, 0.1316468286, 0.1950346411, 0.1823326589, 0.1371594429, 0.09430297914, 0.1064272021,
0.07635461315, 0.2550847952, 0.01128225616, 0.01037186352, 0.03521975419, 0.0007382077955]

```

$$\beta := (t, k2a, k2b, k2c) \mapsto \begin{cases} (-0.02857142857 \cdot k2a + 0.02857142857 \cdot k2b) \cdot t + 1.571428571 \cdot k2a - 0.5714285714 \cdot k2b & t < 55. \\ (-0.02857142857 \cdot k2b + 0.02857142857 \cdot k2c) \cdot t + 2.571428571 \cdot k2b - 1.571428571 \cdot k2c & t < 90. \\ k2c & 90. \leq t \end{cases}$$

```

res := [t=proc(t) ... end proc, A(t)=proc(t) ... end proc, B(t)=proc(t) ... end proc, C(t)=proc(t) ... end proc, Q(t)=proc(t)

```

...

```

end proc]

```

```

[17.41497486, 612241.5749, 0.1316468286, 0.1950346411, 0.1823326589, 0.1371594429, 0.09430297914, 0.1064272021, 0.07635461315,
0.2550847952, 0.01128225616, 0.01037186352, 0.03521975419, 0.0007382077955]

```

55941.1433705998

55941.1433705998

46479.0983617016

40262.8367621260

28969.1948973208  
24492.9180700178  
23788.3461461685  
23300.6565044660  
21528.1590366290  
20762.1636711823  
20590.6195818630  
20464.1782333007  
19707.4327353558  
19168.0598124802  
19062.4784686710  
18982.4824103466  
18272.9018668433  
17775.5080002109  
17720.8079219223  
17679.7050182055  
17411.3432122176  
17204.4772436221  
17164.1558348019  
17133.6999762540  
17094.3282377218  
17067.3223393790  
16864.9490210412  
16714.9011553629  
16678.8022242369  
16647.2827042719  
16519.2972941890  
16412.2498084585  
16385.4895605070  
16364.7727851846

16299.3956007769  
16248.9552719779  
16218.9065455065  
16196.8913690995  
16129.7844827621  
16076.3187140418  
16046.6442967278  
16025.8595619177  
15996.5914632285  
15976.9106682730  
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15920.3259650576  
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15786.9324473563  
15768.1378381713  
15736.3036110991  
15713.0146550463  
15689.0898020970  
15674.0500798970  
15647.8152931596  
15630.9791397115  
15610.5494004726  
15595.5891078300  
15553.7126257101  
15522.9011413331  
15517.0971081194  
15502.1977847062

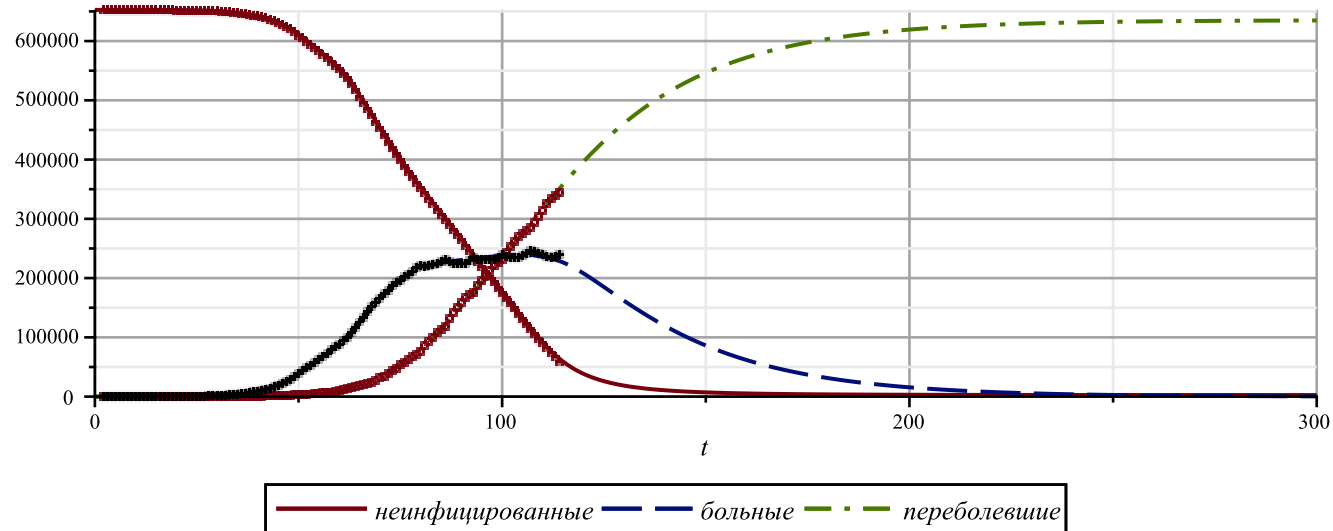
15494.9148030114  
15464.1073339890  
15438.8665532300  
15423.2564529865  
15411.6455564896  
15381.6062094139  
15363.1267294240  
15342.5893218861  
15330.4314952170  
15310.2329778692  
15296.6731713330  
15260.4200644298  
15233.5122568186  
15228.3160051704  
15216.2224261522  
15208.1532995598  
15178.2996230010  
15155.8389454242  
15152.0698268633  
15132.0371418745  
15118.9389836274  
15106.0955032214  
15098.1084119173  
15078.7015290155  
15064.6850048210  
15047.3985474079  
15035.8315011412  
15019.0214028230  
15007.0498421320  
14990.6080840956

14982.3144358083  
14968.2794331854  
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14943.6002650841  
14930.9756935385  
14908.4030076339  
14891.8123190925  
14888.0271556609  
14878.8854795920  
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14859.4196430222  
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14843.9547182114  
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14829.6021633423  
14816.2235275378  
14805.9550957556  
14802.0980393233  
14793.0981032881  
14789.7158746564  
14765.8103217167  
14744.9658283118  
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14632.5185160447  
14543.4402012618  
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14512.3312813847

14506.5957100978  
14504.0414258549  
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14494.0940499229  
14477.8522410719  
14465.9638909458  
14463.7469242116  
14456.8091769062  
14452.6416853884  
14439.3648029360  
14430.3090083159  
14428.5995456782  
14421.8961256427  
14418.8173447880  
14403.9142957265  
14393.7826134357  
14391.5241284492  
14383.5624739654  
14380.5592941559  
14369.6565933059  
14362.2768979009  
14360.1438874930  
14353.2098483679  
14349.1455005891  
14346.5483245466  
14340.6492323135  
14338.8115510708  
14316.1360411671  
14301.4994425365  
14300.2875591489

```
val := [17.4603609794319, 652633.062244007, 0.131966601542310, 0.194618209771725, 0.182414237709935, 0.136368149455143,
0.0941338089852521, 0.104255566008923, 0.0732050915916849, 0.257125802095960, 0.0112850036964795, 0.0104307459669400,
0.0350848817980981, 0.000733252112497956]
```

14300.2875591489  
"Russia3b.jpg"



```
> display(
  plot(map(q->q(t),v), t = 0 .. 300, legend = [ '\ ', '\ ', '\ ', '\ ' ],
    linestyle=[solid,dash,dashdot,dot],gridlines=true),
  plot([[seq([i+dd,K_-T[i]],i=1..nops(T))]],style=point,symbolsize=7,symbol=asterisk),
  plot([[seq([i+dd,T1[i]],i=1..nops(T1))]],style=point,symbolsize=7,symbol=circle),
  plot([[seq([i+dd,T3[i]],i=1..nops(T1))]],style=point,symbolsize=7,symbol=circle),
  plot([[seq([i+dd,T2[i]],i=1..nops(T2))]],style=point,symbolsize=7,symbol=diamond,color=black),
  size=[1000,400],legendstyle=[font=[roman,15]],view=[0..300,0..10000]
);
```

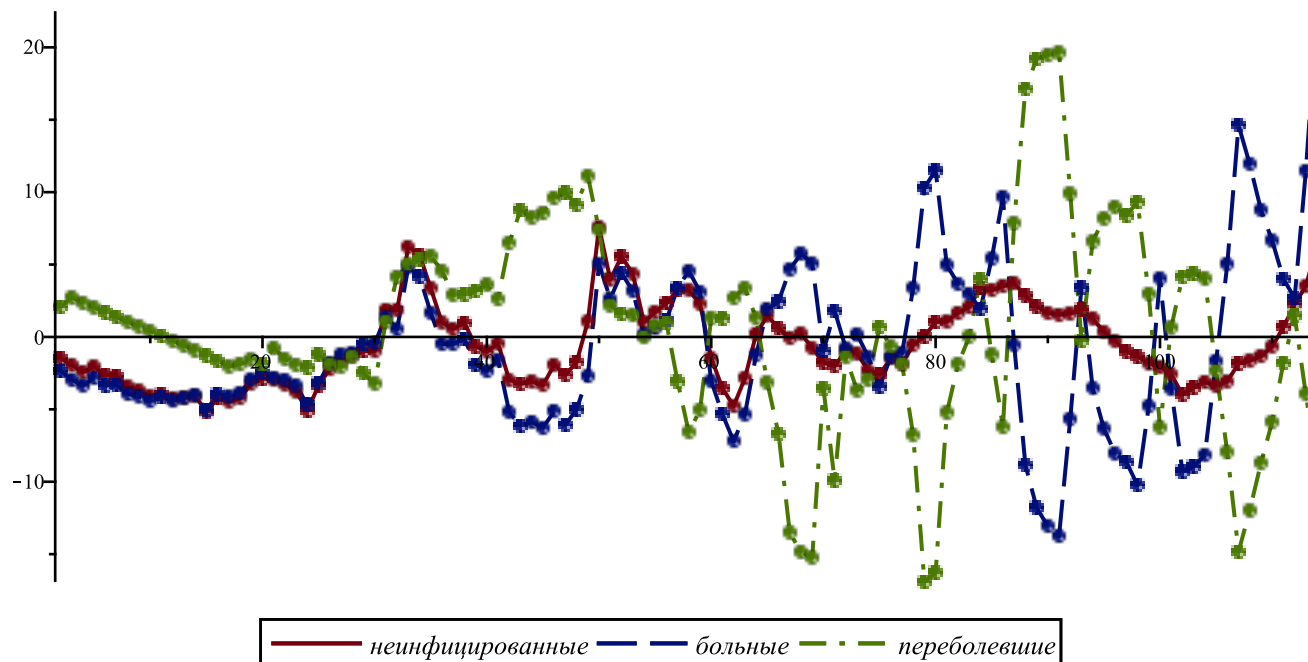




```
]:
```

```
display(  
  plot(% , linestyle=[solid,dash,dashdot], legend = [ '\`', '\`', '\`' ] ,  
  plot(% , style=point, symbolsize=8, symbol=solidcircle) ,  
  size=[1000,500] , legendstyle=[font=[roman,15]]  
) : fdisplay(cat(Region, "3b-dev") , %);
```

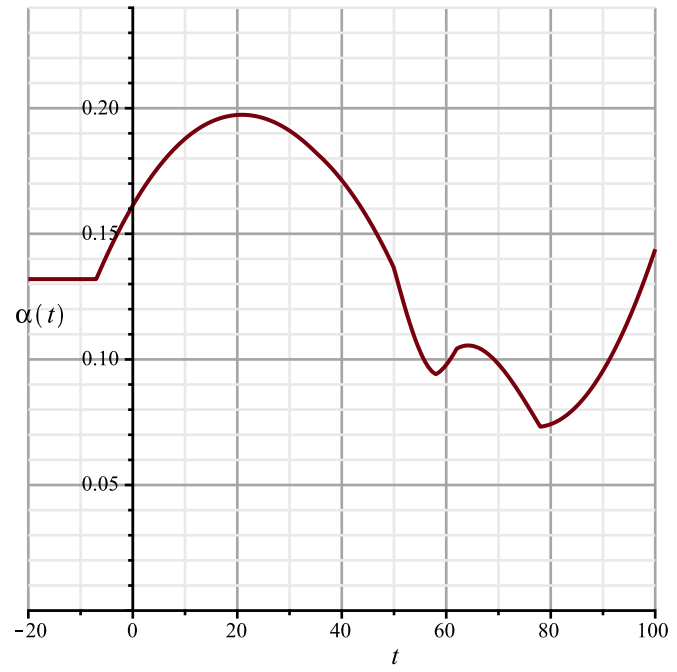
"Russia3b-dev.jpg"



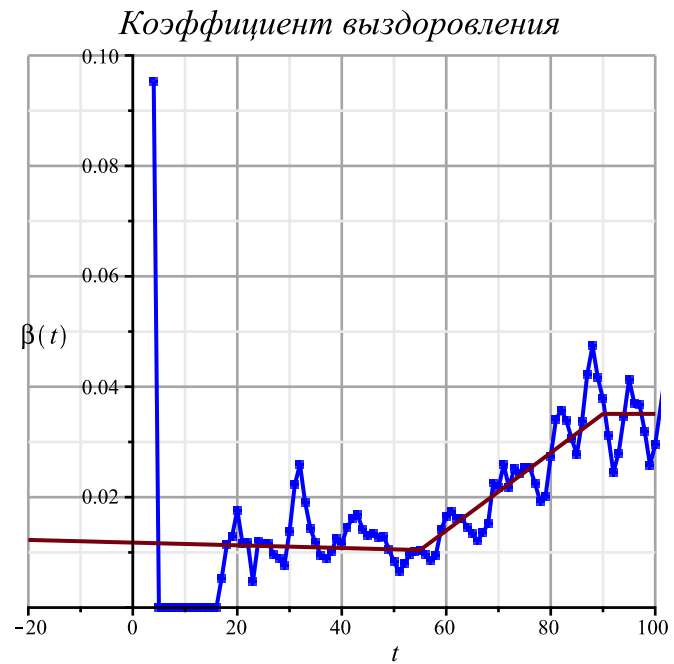
```
> [seq([i, (  
  (T[i-dd]-T[i-dd-1]) / (T2[i-dd]+T2[i-dd-1]) / ((1-T[i-dd]/K_) + (1-T[i-dd-1]/K_))  
)*4], i=1+dd+1..nops(T)+dd)]: [seq([%[i][1], (%[i-1][2]+%[i][2]+%[i+1][2])/3], i=2..nops(%)-1)]:  
Palpha:=display(plot([%], color=blue), plot([%], style=point, symbolsize=8, symbol=solidcircle, color=  
blue)):  
#display(% , gridlines=true, labels=['t', 'alpha(t)'], labelfont=[roman,15], view=[0..nops(T)+dd, 0.  
.0.9]);  
  
subs(corr(par, val), alpha(t, op(kA)));  
plot(% , t=-20..100, gridlines=true, labels=['t', 'alpha(t)'], labelfont=[roman,15], view=[-20..100, 0.
```

```
.0.24]) :
fdisplay(cat(Region,"3b-zar"),%); display([Palpha,%],t i t l e = ` ` ,titlefont=
[roman,20]);
```

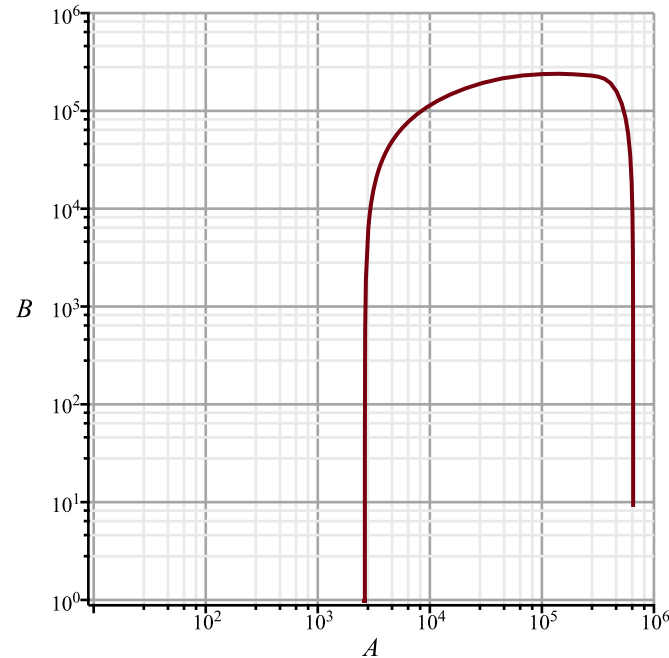
0.131966601542310	$t < -7.$
$2.11591578832368 \cdot 10^{-7} t^3 - 0.0000914317472588865 t^2 + 0.00354349537724984 t + 0.161323800701951$	$t < 35.$
$-5.99882489324720 \cdot 10^{-7} t^3 - 0.0000102843381697792 t^2 + 0.00108878625804111 t + 0.182624995630353$	$t < 50.$
$0.0000276621674560134 t^3 - 0.00405175749325007 t^2 + 0.189879280370059 t - 2.68597307744200$	$t < 58.$
$-0.0000312273456833674 t^3 + 0.00595945975703622 t^2 - 0.375224488779553 t + 7.90236139304823$	$t < 62.$
$6.41291462956521 \cdot 10^{-6} t^3 - 0.00149331179271257 t^2 + 0.112442724742440 t - 2.65527995143949$	$t < 78.$
$0.000135568524561464 t^2 - 0.0209202480853181 t + 0.880185539220272$	$t < 114.$
0.257125802095960	$114. \leq t$
"Russia3b-zar.jpg"	







```
> plot([v[1](t),v[2](t),t=0..3.0e4],labels=[v[1],v[2]],labelfont=[roman,15],gridlines=true,view=[10^1..10^6,10^0..10^6],axis[1]=[mode=log],axis[2]=[mode=log]);
```



```

> res:=solve(map(rhs,eqs[1..2]),v[1..2]); res:=res[2]; evalf(subs(param,t=100,res));

J:=Matrix(subs(res,map(q->grad(rhs(q),v[1..2]),eqs[1..2]))); J:=evalf(subs(param,corr(par,val),t=
100,J));
evalm(%-lambda): collect(Determinant(%),lambda);

#evalf(subs(param,corr(par,val),t=100,%));
solve(%,{lambda});

```

$$\text{res} := \left[ \left[ A = \frac{C P_{01}}{P_{10} - P_{01}}, B = 0 \right], \left[ A = \frac{k0 (P_{23} + P_{20})}{P_{12}}, B = \frac{C P_{01} P_{12} + k0 P_{01} P_{20} + k0 P_{01} P_{23} - k0 P_{10} P_{20} - k0 P_{10} P_{23}}{P_{12} (P_{23} + P_{20})} \right] \right]$$

$$\text{res} := \left[ A = \frac{k0 (P_{23} + P_{20})}{P_{12}}, B = \frac{C P_{01} P_{12} + k0 P_{01} P_{20} + k0 P_{01} P_{23} - k0 P_{10} P_{20} - k0 P_{10} P_{23}}{P_{12} (P_{23} + P_{20})} \right]$$

$$\left[ A = \frac{k0 (k2c + k3)}{-0.37019231 k1x6 + 0.92361112 k1x7 + 0.446581197 k1x8}, B = 0. \right]$$

$$J := \begin{bmatrix} P_{01} - \frac{C P_{01} P_{12} + k_0 P_{01} P_{20} + k_0 P_{01} P_{23} - k_0 P_{10} P_{20} - k_0 P_{10} P_{23}}{(P_{23} + P_{20}) k_0} & -P_{10} & -P_{23} & -P_{20} \\ \frac{C P_{01} P_{12} + k_0 P_{01} P_{20} + k_0 P_{01} P_{23} - k_0 P_{10} P_{20} - k_0 P_{10} P_{23}}{(P_{23} + P_{20}) k_0} & & & 0 \end{bmatrix}$$

$$J := \begin{bmatrix} 0. & -0.0358181339105960 \\ 0. & 0. \end{bmatrix}$$

$$\lambda^2$$

$$\{\lambda=0\}, \{\lambda=0\}$$

(10)

```
> N:='N': A:='A': B:='B': C:='C': Q:='Q':
```

```
param:=[
  P[`01`] = kappa, P[`12`] = k1, P[`23`] = k2,
  P[`10`] = kappa, P[`20`] = k3, P[`30`] = k4
];
corr(par, val);
subs(param, eqs); R:=solve(%, [k1, k2, k3, k4])[1];
```

```
X:='X': X1:='X1': subs(R, Diff(A, t) = -X1[1][i][2], Diff(B, t) = X1[2][i][2], Diff(C, t) = X1[3][i][2], Diff
(Q, t) = X1[4][i][2], A = k0 - X[1][i][2], B = X[2][i][2], C = X[3][i][2], Q = X[4][i][2], [k1, k2, k3, k4]): XX:=
unapply(subs(k0=K_, %), i):
```

$$param := [P_{01} = 0, P_{12} = k1, P_{23} = k2, P_{10} = 0, P_{20} = k3, P_{30} = k4]$$

```
d0 = 17.4603609794319, k0 = 652633.062244007, k1x1 = 0.131966601542310, k1x2 = 0.194618209771725, k1x3 = 0.182414237709935, k1x4
= 0.136368149455143, k1x5 = 0.0941338089852521, k1x6 = 0.104255566008923, k1x7 = 0.0732050915916849, k1x8
= 0.257125802095960, k2a = 0.0112850036964795, k2b = 0.0104307459669400, k2c = 0.0350848817980981, k3
= 0.000733252112497956
```

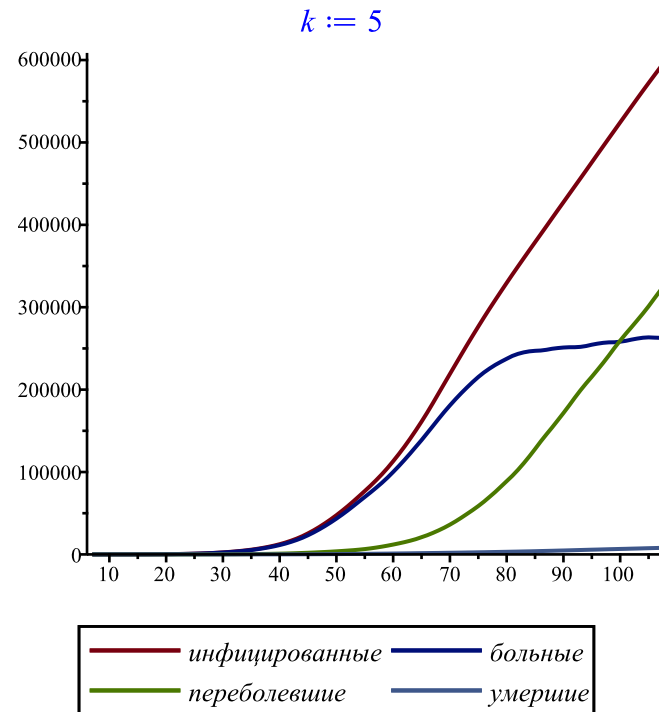
$$\left[ \frac{\partial}{\partial t} A = -\frac{B k_1 A}{k_0}, \frac{\partial}{\partial t} B = \frac{B k_1 A}{k_0} - k_2 B - k_3 B, \frac{\partial}{\partial t} C = k_2 B - C k_4, \frac{\partial}{\partial t} Q = k_3 B \right]$$

$$R := \left[ k1 = -\frac{\frac{\partial}{\partial t} A k0}{AB}, k2 = -\frac{\frac{\partial}{\partial t} A + \frac{\partial}{\partial t} B + \frac{\partial}{\partial t} Q}{B}, k3 = \frac{\frac{\partial}{\partial t} Q}{B}, k4 = -\frac{\frac{\partial}{\partial t} A + \frac{\partial}{\partial t} B + \frac{\partial}{\partial t} Q + \frac{\partial}{\partial t} C}{C} \right] \quad (11)$$

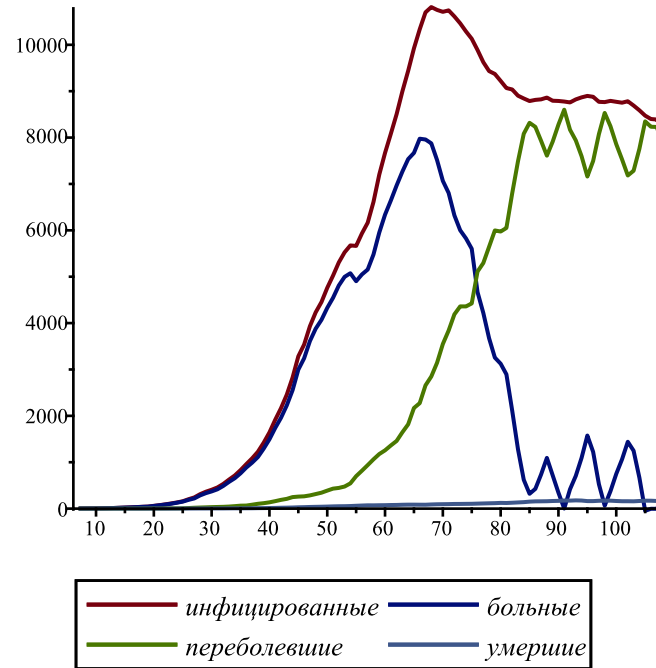
```

> k:=5;
X:=map(q->[seq([i+dd, (ssum(q[i+j], j=-k..k)) / (2*k)], i=1+k..nops(q)-k)], [T, T2, T1, T3]):
plot(%, legend=[' ', ' ', ' ', ' '], legendstyle=[font=[roman, 15]]);
X1:=map(q->[seq([i+dd, (q[i+k]-q[i-k]) / (2*k)], i=1+k..nops(q)-k)], [T, T2, T1, T3]):
plot(%, legend=[' ', ' ', ' ', ' '], legendstyle=[font=[roman, 15]]);

```







```
> k:=0;
```

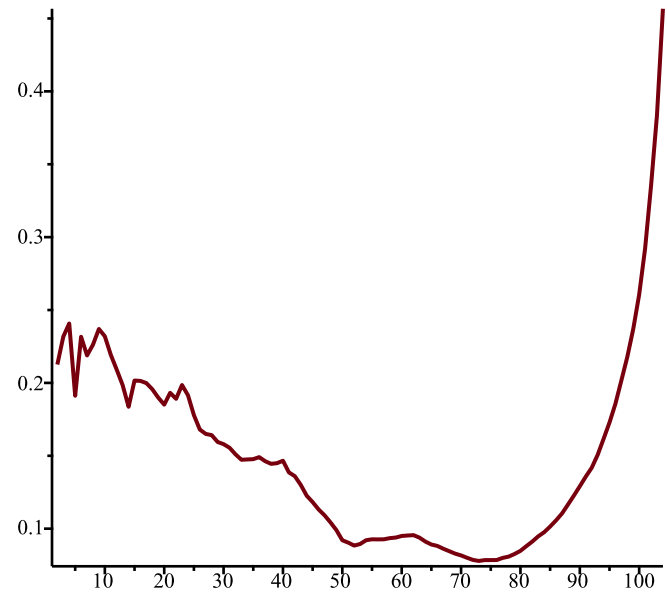
```
[seq([i+dd+k,XX(i)[1]],i=1..nops(X[1]))]: [seq([%[i][1],(ssum(%[i+j][2],j=-k..k))/(2*k+1)],i=1+k..nops(%)-k)]:
plot([%],title=P[`12`],titlefont=[roman,20]);
```

```
[seq([i+dd+k,XX(i)[2]],i=1..nops(X[1]))]: [seq([%[i][1],(ssum(%[i+j][2],j=-k..k))/(2*k+1)],i=1+k..nops(%)-k)]:
plot([%],title=P[`23`],titlefont=[roman,20]);
```

```
[seq([i+dd+k,XX(i)[3]],i=1..nops(X[1]))]: [seq([%[i][1],(ssum(%[i+j][2],j=-k..k))/(2*k+1)],i=1+k..nops(%)-k)]:
plot([%],title=P[`20`],titlefont=[roman,20]);
```

```
k := 0
```

$P_{12}$



$P_{23}$



$P_{20}$

