```
> restart;
  with(plots):
  with(StringTools):
  with(LinearAlgebra):
  with(DEtools):

  ##########################################################################################

  Region:=`Mosobl`; url:="https://gogov.ru/covid-19/mo#data";

  #valp := [12.0545284599666, 40487.7036090492, 0.0878540675828671, 0.119034763474605,
  0.208571881538399, 0.163876229453231, #0.0804863589181470, 0.0940935501988715, 0.105057419991328,
  0.104244846871936, 0.00441107479765352, 0.00987259141378349, #0.0000931839501779284];

  valp:=readdata(cat(Region,`3c.txt`));
  #valp:=[13.51351539, 60412.96696, 0.1007399931, 0.1125440131, 0.2130928266, 0.1556319126,
  0.07614930869, 0.07804499825, #0.07915349053, 0.1233558069, 0.007192627605, 0.00339175117,
  0.01641051065, 0.0006085575277];

  ##########################################################################################

  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:
```

$$Region := Mosobl$$

$$url := \text{"https://gogov.ru/covid-19/mo\#data"}$$

$$valp := [13.44258404, 62802.67494, 0.1012133281, 0.1111242458, 0.2115507857, 0.1595470238, 0.08751331813, 0.08130220975, 0.07749483653, 0.1277152111, 0.007412379613, 0.01037824493, 0.0236434147, 0.0006037801923]$$

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

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

$$\pi := 3.141592654$$

(1

```
> dig:={"0","1","2","3","4","5","6","7","8","9","0"}: val:=proc() global data,i; local j,f; f:=0;
   while not(data[i] in dig) or f=1 and data[i] in {"+"} union dig do:
   if f=1 and not(data[i] in dig) then f:=0; else if data[i]="+" then f:=1; fi fi; i:=i+1: od:
   j:=i; while (data[i] in dig or data[i] in {"-","+"}) do i:=i+1: od: parse(data[j..i-1]);
  end:
  ` `; Region; status,data,headers:=HTTP:-Get(url): HTTP:-Code(status); i:=Search("<th>",data):

  iter:=proc() global i; local r;
   r:=val(); if data[i]<>"." then NULL else [r,val(),val(),val(),val(),val()],iter() fi;
  end:

  [iter()]: tA:=[seq(%[nops(%)+1-i],i=1..nops(%))];
  dd:=tA[1][1]+piecewise(tA[1][2]=2,-29,tA[1][2]=4,31,0)-1;
  T:=map(q->q[4],tA): #writedata(Region || `-i.txt`,%): #
  T3:=map(q->q[5],tA): #writedata(Region || `-m.txt`,%): #
  T1:=map(q->q[6],tA): #writedata(Region || `-r.txt`,%): #
  T2:=[seq(T[i]-(T1[i]+T3[i]),i=1..nops(T))]: #writedata(Region || `-h.txt`,%): #
  i:='i':
  Region; 'T'=T; 'T1'=T1; 'T2'=T2; 'T3'=T3;

  nops(T); [i+dd $ i=1..%];
```

``

Mosobl

"OK"

$$tA := [[8, 3, 20, 1, 0, 0], [9, 3, 20, 1, 0, 0], [10, 3, 20, 1, 0, 0], [11, 3, 20, 3, 0, 0], [12, 3, 20, 3, 0, 0], [13, 3, 20, 4, 0, 0], [14, 3, 20, 5, 0, 0],$$

[15, 3, 20, 8, 0, 0], [16, 3, 20, 9, 0, 0], [17, 3, 20, 11, 0, 0], [18, 3, 20, 12, 0, 0], [19, 3, 20, 17, 0, 0], [20, 3, 20, 18, 0, 1], [21, 3, 20, 35, 0, 1], [22, 3, 20, 35, 0, 1], [23, 3, 20, 35, 0, 1], [24, 3, 20, 35, 0, 2], [25, 3, 20, 41, 0, 7], [26, 3, 20, 41, 0, 7], [27, 3, 20, 49, 0, 8], [28, 3, 20, 85, 0, 8], [29, 3, 20, 112, 0, 10], [30, 3, 20, 119, 0, 10], [31, 3, 20, 119, 0, 14], [1, 4, 20, 134, 1, 17], [2, 4, 20, 177, 2, 17], [3, 4, 20, 211, 2, 17], [4, 4, 20, 260, 2, 30], [5, 4, 20, 305, 2, 33], [6, 4, 20, 387, 3, 34], [7, 4, 20, 454, 8, 47], [8, 4, 20, 549, 10, 50], [9, 4, 20, 748, 13, 52], [10, 4, 20, 930, 13, 66], [11, 4, 20, 1082, 14, 69], [12, 4, 20, 1360, 18, 75], [13, 4, 20, 1855, 19, 75], [14, 4, 20, 2315, 24, 75], [15, 4, 20, 2587, 26, 75], [16, 4, 20, 3054, 33, 91], [17, 4, 20, 3526, 40, 105], [18, 4, 20, 3954, 40, 126], [19, 4, 20, 4663, 49, 162], [20, 4, 20, 5241, 49, 176], [21, 4, 20, 5959, 49, 179], [22, 4, 20, 6590, 56, 186], [23, 4, 20, 7278, 56, 186], [24, 4, 20, 7889, 66, 235], [25, 4, 20, 8494, 69, 262], [26, 4, 20, 9070, 71, 272], [27, 4, 20, 9708, 71, 286], [28, 4, 20, 10231, 74, 311], [29, 4, 20, 10917, 90, 389], [30, 4, 20, 11710, 93, 430], [1, 5, 20, 12507, 109, 458], [2, 5, 20, 13314, 109, 503], [3, 5, 20, 14136, 111, 507], [4, 5, 20, 14939, 111, 526], [5, 5, 20, 15761, 127, 576], [6, 5, 20, 16590, 141, 611], [7, 5, 20, 17432, 156, 769], [8, 5, 20, 18350, 175, 813], [9, 5, 20, 19425, 186, 1030], [10, 5, 20, 20558, 195, 1236], [11, 5, 20, 21637, 209, 1389], [12, 5, 20, 22700, 219, 1582], [13, 5, 20, 23662, 226, 1745], [14, 5, 20, 24580, 240, 1987], [15, 5, 20, 25525, 253, 2468], [16, 5, 20, 26462, 262, 2724], [17, 5, 20, 27369, 268, 3088], [18, 5, 20, 28290, 268, 3361], [19, 5, 20, 29188, 271, 3614], [20, 5, 20, 30091, 285, 3897], [21, 5, 20, 30983, 299, 4281], [22, 5, 20, 31807, 312, 4699], [23, 5, 20, 32653, 324, 5163], [24, 5, 20, 33515, 329, 5520], [25, 5, 20, 34346, 340, 5908], [26, 5, 20, 35163, 349, 6152], [27, 5, 20, 35956, 359, 6440], [28, 5, 20, 36730, 380, 6843], [29, 5, 20, 37503, 400, 7333], [30, 5, 20, 38238, 424, 7720], [31, 5, 20, 38995, 449, 8091], [1, 6, 20, 39723, 473, 8422], [2, 6, 20, 40455, 495, 8809], [3, 6, 20, 41191, 515, 9311], [4, 6, 20, 41958, 534, 9877], [5, 6, 20, 42720, 539, 10392], [6, 6, 20, 43478, 557, 10924], [7, 6, 20, 44232, 567, 11462], [8, 6, 20, 44983, 578, 12031], [9, 6, 20, 45722, 590, 12672], [10, 6, 20, 46457, 622, 13419], [11, 6, 20, 47181, 644, 14187], [12, 6, 20, 47911, 666, 14955], [13, 6, 20, 48636, 678, 15734], [14, 6, 20, 49353, 678, 16573], [15, 6, 20, 50042, 690, 17422], [16, 6, 20, 50736, 702, 18340], [17, 6, 20, 51416, 728, 19319], [18, 6, 20, 52083, 751, 20355], [19, 6, 20, 52729, 755, 21448], [20, 6, 20, 53320, 778, 22596], [21, 6, 20, 53869, 783, 23798], [22, 6, 20, 54375, 783, 25036], [23, 6, 20, 54879, 798, 26198]]

$$dd := 7$$

$$Mosobl$$

T = [1, 1, 1, 3, 3, 4, 5, 8, 9, 11, 12, 17, 18, 35, 35, 35, 35, 41, 41, 49, 85, 112, 119, 119, 134, 177, 211, 260, 305, 387, 454, 549, 748, 930, 1082, 1360, 1855, 2315, 2587, 3054, 3526, 3954, 4663, 5241, 5959, 6590, 7278, 7889, 8494, 9070, 9708, 10231, 10917, 11710, 12507, 13314, 14136, 14939, 15761, 16590, 17432, 18350, 19425, 20558, 21637, 22700, 23662, 24580, 25525, 26462, 27369, 28290, 29188, 30091, 30983, 31807, 32653, 33515, 34346, 35163, 35956, 36730, 37503, 38238, 38995, 39723, 40455, 41191, 41958, 42720, 43478, 44232, 44983, 45722, 46457, 47181, 47911, 48636, 49353, 50042, 50736, 51416, 52083, 52729, 53320, 53869, 54375, 54879]

TI = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 2, 7, 7, 8, 8, 10, 10, 14, 17, 17, 17, 30, 33, 34, 47, 50, 52, 66, 69, 75, 75, 75, 75, 91, 105, 126, 162, 176, 179, 186, 186, 235, 262, 272, 286, 311, 389, 430, 458, 503, 507, 526, 576, 611, 769, 813, 1030, 1236, 1389, 1582, 1745, 1987,

2468, 2724, 3088, 3361, 3614, 3897, 4281, 4699, 5163, 5520, 5908, 6152, 6440, 6843, 7333, 7720, 8091, 8422, 8809, 9311, 9877, 10392, 10924, 11462, 12031, 12672, 13419, 14187, 14955, 15734, 16573, 17422, 18340, 19319, 20355, 21448, 22596, 23798, 25036, 26198]

$T2$ = [1, 1, 1, 3, 3, 4, 5, 8, 9, 11, 12, 17, 17, 34, 34, 34, 33, 34, 34, 41, 77, 102, 109, 105, 116, 158, 192, 228, 270, 350, 399, 489, 683, 851, 999, 1267, 1761, 2216, 2486, 2930, 3381, 3788, 4452, 5016, 5731, 6348, 7036, 7588, 8163, 8727, 9351, 9846, 10438, 11187, 11940, 12702, 13518, 14302, 15058, 15838, 16507, 17362, 18209, 19127, 20039, 20899, 21691, 22353, 22804, 23476, 24013, 24661, 25303, 25909, 26403, 26796, 27166, 27666, 28098, 28662, 29157, 29507, 29770, 30094, 30455, 30828, 31151, 31365, 31547, 31789, 31997, 32203, 32374, 32460, 32416, 32350, 32290, 32224, 32102, 31930, 31694, 31369, 30977, 30526, 29946, 29288, 28556, 27883]

$T3$ = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 2, 2, 2, 2, 3, 8, 10, 13, 13, 14, 18, 19, 24, 26, 33, 40, 40, 49, 49, 49, 56, 56, 66, 69, 71, 71, 74, 90, 93, 109, 109, 111, 111, 127, 141, 156, 175, 186, 195, 209, 219, 226, 240, 253, 262, 268, 268, 271, 285, 299, 312, 324, 329, 340, 349, 359, 380, 400, 424, 449, 473, 495, 515, 534, 539, 557, 567, 578, 590, 622, 644, 666, 678, 678, 690, 702, 728, 751, 755, 778, 783, 783, 798]

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[8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115] **(2**

```
> `====================================`;
  `VERHULST FItAING`;
  `====================================`;
```

==========

VERHULST FItAING

========== **(3**

```
> 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
  );
```

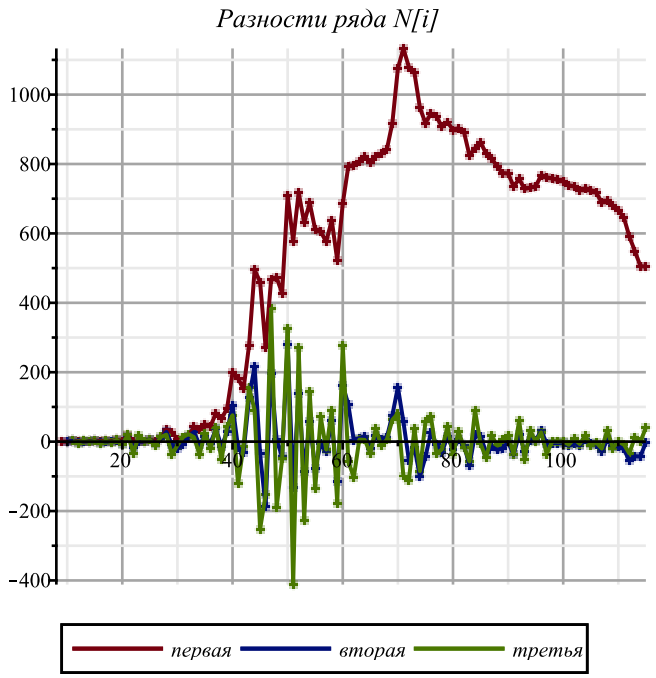
```
[seq((h(T[i])-h(T[i-5]))/5.,i=6..nops(T))]: [seq((%[i]-%[i-3])/3.,i=4..nops(%))]: [seq((%[i]-%
[i-3])/3.,i=4..nops(%))]:
[seq([i+dd+2,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+4,%%%[i]],i=1..nops(%%%))]: [seq([i+dd+6,%%%[i]
],i=1..nops(%%%))]:
display(
 plot([%%%,%%,%],style=point),
  plot([%%%,%%,%],legend=[``,``,``]),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

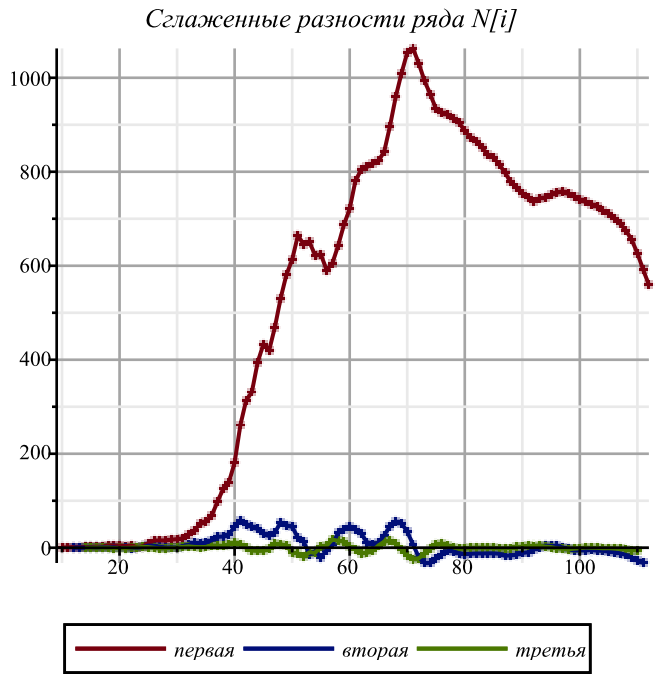
$$h := x \mapsto x$$

$$[0, 0, 2, 0, 1, 1, 3, 1, 2, 1, 5, 1, 17, 0, 0, 0, 6, 0, 8, 36, 27, 7, 0, 15, 43, 34, 49, 45, 82, 67, 95, 199, 182, 152, 278, 495, 460, 272, 467, 472, 428, 709, 578, 718, 631, 688, 611, 605, 576, 638, 523, 686, 793, 797, 807, 822, 803, 822, 829, 842, 918, 1075, 1133, 1079, 1063, 962, 918, 945, 937, 907, 921, 898, 903, 892, 824, 846, 862, 831, 817, 793, 774, 773, 735, 757, 728, 732, 736, 767, 762, 758, 754, 751, 739, 735, 724, 730, 725, 717, 689, 694, 680, 667, 646, 591, 549, 506, 504]$$

$$[0, 2, -2, 1, 0, 2, -2, 1, -1, 4, -4, 16, -17, 0, 0, 6, -6, 8, 28, -9, -20, -7, 15, 28, -9, 15, -4, 37, -15, 28, 104, -17, -30, 126, 217, -35, -188, 195, 5, -44, 281, -131, 140, -87, 57, -77, -6, -29, 62, -115, 163, 107, 4, 10, 15, -19, 19, 7, 13, 76, 157, 58, -54, -16, -101, -44, 27, -8, -30, 14, -23, 5, -11, -68, 22, 16, -31, -14, -24, -19, -1, -38, 22, -29, 4, 4, 31, -5, -4, -4, -3, -12, -4, -11, 6, -5, -8, -28, 5, -14, -13, -21, -55, -42, -43, -2]$$

$$[2, -4, 3, -1, 2, -4, 3, -2, 5, -8, 20, -33, 17, 0, 6, -12, 14, 20, -37, -11, 13, 22, 13, -37, 24, -19, 41, -52, 43, 76, -121, -13, 156, 91, -252, -153, 383, -190, -49, 325, -412, 271, -227, 144, -134, 71, -23, 91, -177, 278, -56, -103, 6, 5, -34, 38, -12, 6, 63, 81, -99, -112, 38, -85, 57, 71, -35, -22, 44, -37, 28, -16, -57, 90, -6, -47, 17, -10, 5, 18, -37, 60, -51, 33, 0, 27, -36, 1, 0, 1, -9, 8, -7, 17, -11, -3, -20, 33, -19, 1, -8, -34, 13, -1, 41]$$


Разности ряда N[i]
1000
800
600
400
200
0
-200
-400
20
40
60
80
100
первая
вторая
третья




```
> 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=[``,``,``]),
```

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

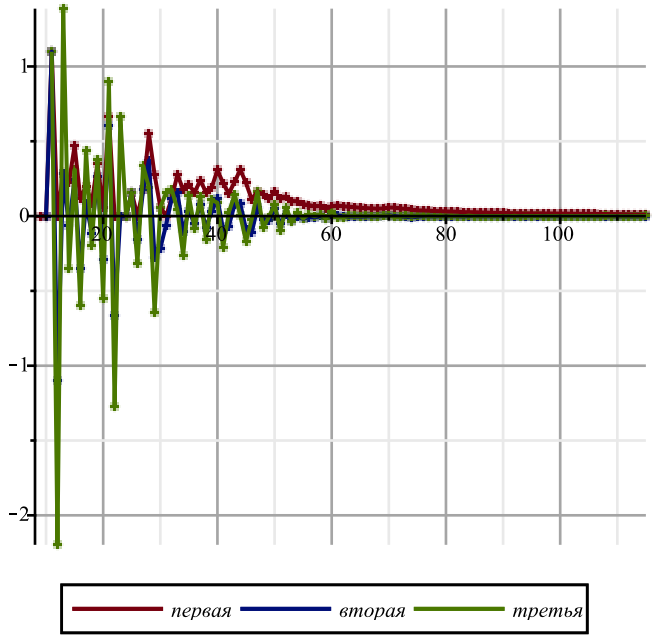
$$h := x \mapsto evalf(\ln(x))$$

[0., 0., 1.098612289, 0., 0.287682072, 0.223143551, 0.470003630, 0.117783036, 0.200670695, 0.087011377, 0.348306694, 0.057158414, 0.664976303, 0., 0., 0., 0.158224006, 0., 0.178248231, 0.550830958, 0.275847615, 0.060624622, 0., 0.118716307, 0.278309933, 0.175708400, 0.208823498, 0.159630146, 0.238112916, 0.159672505, 0.190001244, 0.309304536, 0.217781608, 0.151381873, 0.228673520, 0.310399996, 0.221524992, 0.111089215, 0.165953304, 0.143711877, 0.114563641, 0.164931293, 0.116853302, 0.128390362, 0.100650666, 0.099302751, 0.080613285, 0.073890648, 0.065612232, 0.067978024, 0.052472039, 0.064898880, 0.070121971, 0.065845310, 0.062527625, 0.059908622, 0.055250508, 0.053563291, 0.051261570, 0.049507494, 0.051321976, 0.056931322, 0.056689264, 0.051154652, 0.047960109, 0.04150546, 0.03806272, 0.03772526, 0.03605138, 0.03370125, 0.03309739, 0.03124928, 0.03046846, 0.02921255, 0.02624772, 0.02625034, 0.02605637, 0.02449246, 0.02350883, 0.02230158, 0.02129789, 0.02082707, 0.01940885, 0.01960365, 0.01849693, 0.01825988, 0.01802954, 0.01844934, 0.01799807, 0.01758787, 0.01719345, 0.01683613, 0.01629494, 0.01594757, 0.01546412, 0.01535385, 0.01501888, 0.01463455, 0.01386410, 0.01377307, 0.01331369, 0.01288919, 0.01232699, 0.01114590, 0.01024368, 0.00934932, 0.00922627]

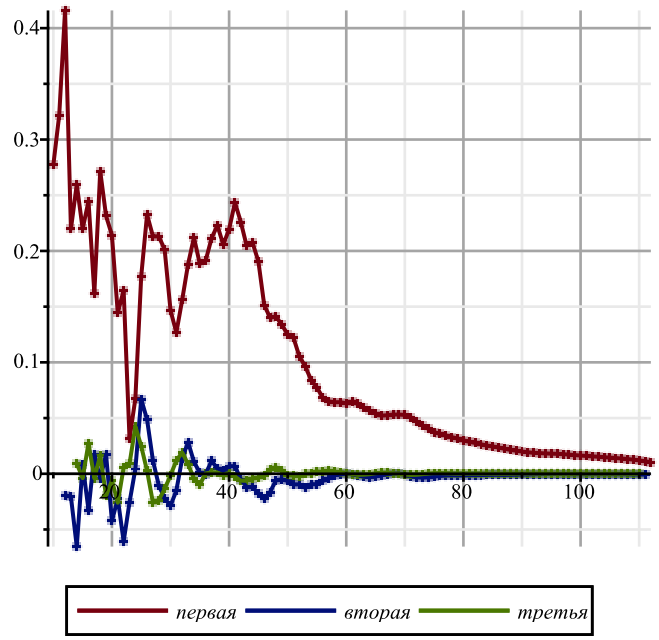
[0., 1.098612289, −1.098612289, 0.287682072, −0.064538521, 0.246860079, −0.352220594, 0.082887659, −0.113659318, 0.261295317, −0.291148280, 0.607817889, −0.664976303, 0., 0., 0.158224006, −0.158224006, 0.178248231, 0.372582727, −0.274983343, −0.215222993, −0.060624622, 0.118716307, 0.159593626, −0.102601533, 0.033115098, −0.049193352, 0.078482770, −0.078440411, 0.030328739, 0.119303292, −0.091522928, −0.066399735, 0.077291647, 0.081726476, −0.088875004, −0.110435777, 0.054864089, −0.022241427, −0.029148236, 0.050367652, −0.048077991, 0.011537060, −0.027739696, −0.001347915, −0.018689466, −0.006722637, −0.008278416, 0.002365792, −0.015505985, 0.012426841, 0.005223091, −0.004276661, −0.003317685, −0.002619003, −0.004658114, −0.001687217, −0.002301721, −0.001754076, 0.001814482, 0.005609346, −0.000242058, −0.005534612, −0.003194543, −0.006454649, −0.00344274, −0.00033746, −0.00167388, −0.00235013, −0.00060386, −0.00184811, −0.00078082, −0.00125591, −0.00296483, $2.62\ 10^{-6}$, −0.00019397, −0.00156391, −0.00098363, −0.00120725, −0.00100369, −0.00047082, −0.00141822, 0.00019480, −0.00110672, −0.00023705, −0.00023034, 0.00041980, −0.00045127, −0.00041020, −0.00039442, −0.00035732, −0.00054119, −0.00034737, −0.00048345, −0.00011027, −0.00033497, −0.00038433, −0.00077045, −0.00009103, −0.00045938, −0.00042450, −0.00056220, −0.00118109, −0.00090222, −0.00089436, −0.00012305]

[1.098612289, −2.197224578, 1.386294361, −0.352220593, 0.311398600, −0.599080673, 0.435108253, −0.196546977, 0.374954635, −0.552443597, 0.898966169, −1.272794192, 0.664976303, 0., 0.158224006, −0.316448012, 0.336472237, 0.194334496, −0.647566070, 0.059760350, 0.154598371, 0.179340929, 0.040877319, −0.262195159, 0.135716631, −0.082308450, 0.127676122, −0.156923181, 0.108769150, 0.088974553, −0.210826220, 0.025123193, 0.143691382, 0.004434829, −0.170601480, −0.021560773, 0.165299866, −0.077105516, −0.006906809, 0.079515888, −0.098445643, 0.059615051, −0.039276756, 0.026391781, −0.017341551, 0.011966829, −0.001555779, 0.010644208, −0.017871777, 0.027932826, −0.007203750, −0.009499752, 0.000958976, 0.000698682, −0.002039111, 0.002970897, −0.000614504, 0.000547645, 0.003568558, 0.003794864, −0.005851404, −0.005292554, 0.002340069, −0.003260106, 0.003011909, 0.00310528, −0.00133642, −0.00067625, 0.00174627, −0.00124425, 0.00106729, −0.00047509, −0.00170892, 0.00296745, −0.00019659, −0.00136994, 0.00058028, −0.00022362, 0.00020356, 0.00053287, −0.00094740, 0.00161302, −0.00130152, 0.00086967, $6.71\ 10^{-6}$, 0.00065014, −0.00087107, 0.00004107, 0.00001578, 0.00003710, −0.00018387, 0.00019382, −0.00013608, 0.00037318, −0.00022470, −0.00004936, −0.00038612, 0.00067942, −0.00036835, 0.00003488, −0.00013770, −0.00061889, 0.00027887, $7.86\ 10^{-6}$, 0.00077131]

Разности ряда ln(N[i])



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(ffe_(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(ffe_(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:
```

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

$$fe\_ := d \mapsto \sum_{j=0}^{ne} a_j \cdot d^j$$

$$ff := x \mapsto M \cdot \left(1 - \frac{1}{e^x + 1}\right)$$

$$ff\_ := y \mapsto \ln\left(\frac{y}{M - y}\right)$$

$$\frac{\left(\frac{1}{M-x} + \frac{x}{(M-x)^2}\right)(M-x)}{x}$$

$$dff\_ := x \mapsto \frac{M}{(M-x)\cdot x}$$

$$ffe := x \mapsto e^x$$

$$ffe\_ := y \mapsto \ln(y)$$

$$\frac{1}{x}$$

$$dffe\_ := x \mapsto \frac{1}{x}$$

$$\sigma := x \mapsto simplify\left(\sqrt{x}\right)$$

$$\chi 2 := (T, f\_) \rightarrow simplify\left(\sum_{k=1}^{nops(T)} \frac{evalf\left(ff\_\left(T_k\right) - f\_(k)\right)^2}{dff\_\left(T_k\right)^2 \sigma\left(T_k\right)^2}\right)$$

$$chi2e := (T, f\_) \rightarrow simplify\left(\sum_{k=1}^{nops(T)} \frac{evalf\left(ffe\_\left(T_k\right) - f\_(k)\right)^2}{dffe\_\left(T_k\right)^2 \sigma\left(T_k\right)^2}\right)$$

(4

```
> 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(ffe(%(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(ffe(%(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

$$M := 54881.42820$$

$$N(t) = 54881.42820 - \frac{54881.42820}{e^{0.08319143551\,t - 5.950746677} + 1}$$

$$Chi2 := 21280.83471$$

Next day forecast: 52554

The level of 0.5 M is reached at 49 apr

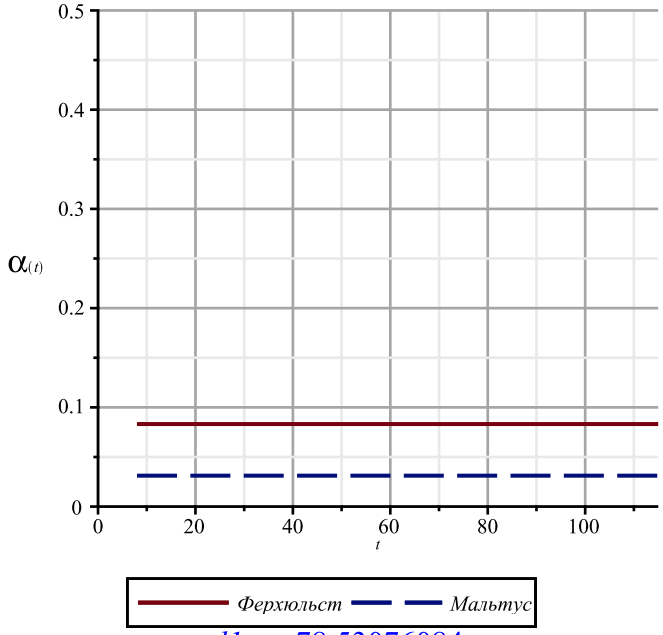
The level of 0.85 M is reached at 69 apr

Approximation of the infection schedule by solving the Malthus equation

$$N(t) = e^{0.03117217699\,t + 7.791741183}$$

$$[0.08319143551]$$

Коэффициент заражения



$d1 := 78.53076084$

$K\_ := 54881.42820$

$alpha\_ := 0.08319143551$

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

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

$M := 58536.90740$

$$N(t) = 58536.90740 - \frac{58536.90740}{e^{-1.575029016\,10^{-8}\,t^4 + 0.00002500972663\,t^3 - 0.005188789106\,t^2 + 0.4408998095\,t - 13.84173837} + 1}$$

$Chi2 := 1582.299972$

Next day forecast: 54964

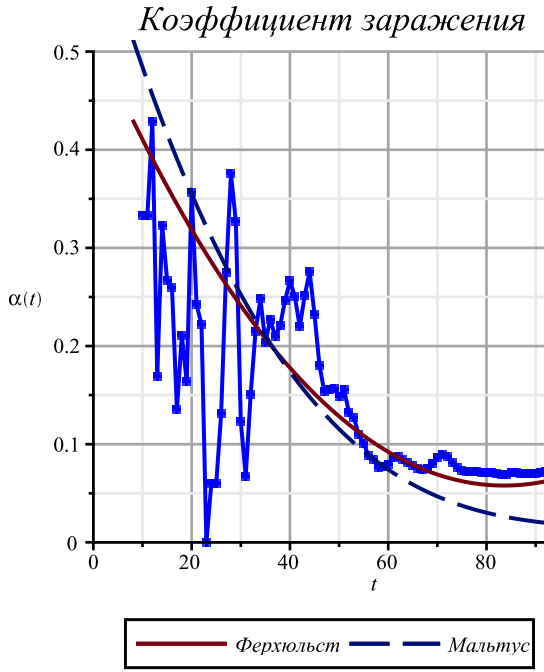
The level of 0.5 M is reached at 50 apr

The level of 0.85 M is reached at 76 apr

Approximation of the infection schedule by solving the Malthus equation

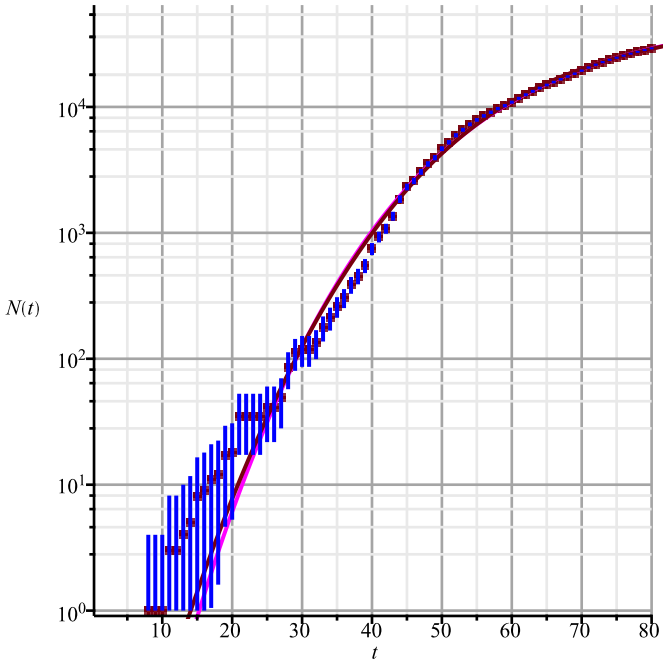
$$N(t) = e^{-1.340055772\,10^{-7}\,t^4 + 0.00005162975904\,t^3 - 0.007638568025\,t^2 + 0.5285831666\,t - 3.882074732}$$

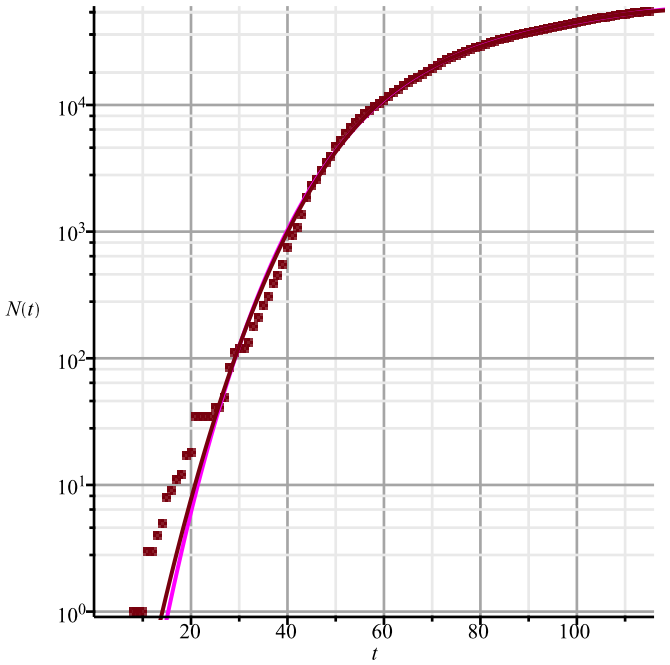
$$[0.517240896200000,\ -0.0114372479000000,\ 0.000076352204260000,\ -6.300116064\,10^{-8}]$$

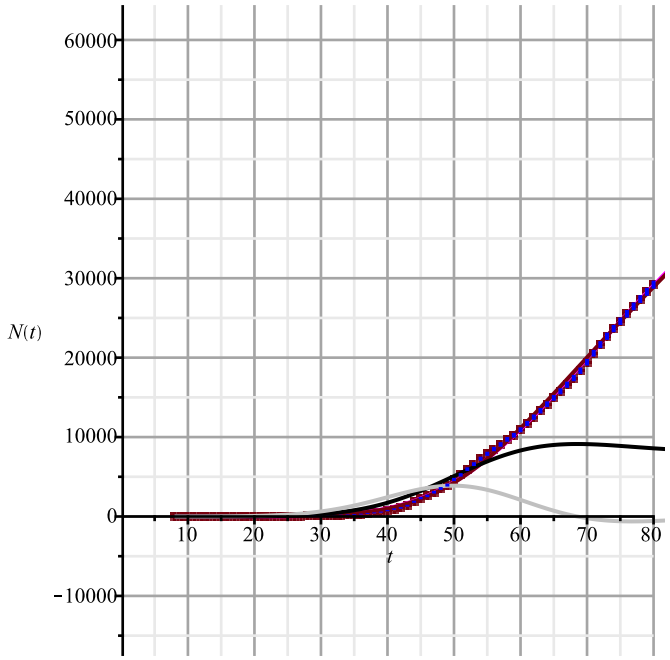


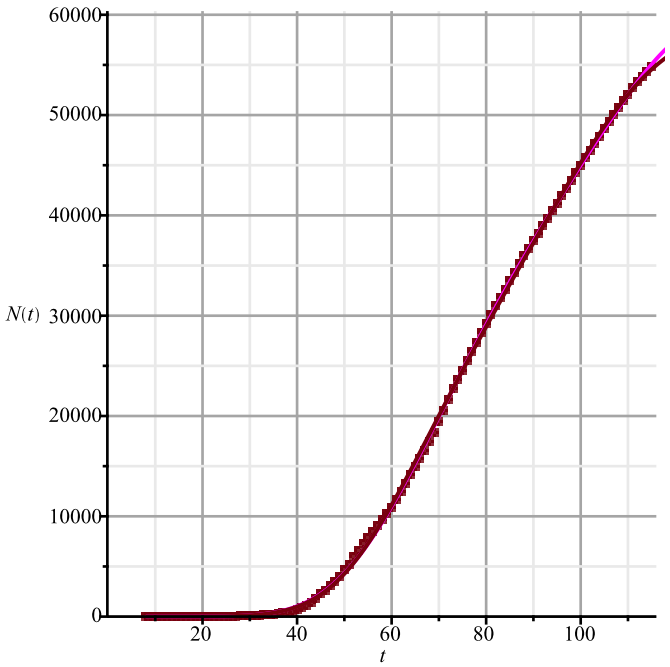

```
> df:=unapply(diff(f(i),i),i): ddf:=unapply(diff(f(i),i,i),i):

  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
);
```


10^4
10^3
$N(t)$
10^2
10^1
10^0
10
20
30
40
50
60
70
80
t

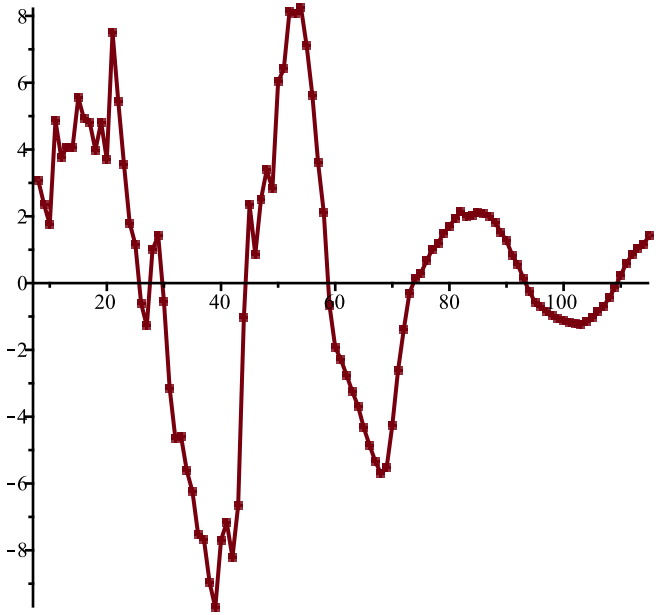

10^4
10^3
$N(t)$
10^2
10^1
10^0
20
40
60
80
100
t


60000
50000
40000
30000
20000
10000
0
-10000
N(t)
10
20
30
40
50
60
70
80
t




```
> 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),t i t l e = ` `     ,titlefont=
  [roman,20] );
```

Девиация




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

==========

FORECAST

==========

(5

```
> 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)=proc1(X),M); Vector(%);
```

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

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

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

(6

$$\left[\begin{array}{c} \frac{\partial}{\partial t} A = (A + C)\, P_{01} - \frac{B\, P_{12}\, A}{K} - P_{10}\, A \\ \frac{\partial}{\partial t} B = \frac{B\, P_{12}\, A}{K} - P_{23}\, B - P_{20}\, B \\ \frac{\partial}{\partial t} C = P_{23}\, B - P_{30}\, C \\ \frac{\partial}{\partial t} Q = P_{20}\, B \end{array}\right] \quad (6$$

```
> v:=M; alpha:='alpha': K:=k0; tA:=[-7,15,35,50,58,62,97,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   ];
```

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

$$K := k0$$

$$tA := [-7, 15, 35, 50, 58, 62, 97, 115]$$

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

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

$$\kappa := 0$$

$$0.00003013698630$$

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

$$init := [A(-d0) = k0, B(-d0) = 1, C(-d0) = 0, Q(-d0) = 0] \quad (7$$

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

$$Eqs := \left[\frac{d}{dt} A(t) = -\frac{B(t)\ \alpha(t, k1x1, k1x2, k1x3, k1x4, k1x5, k1x6, k1x7, k1x8)\ A(t)}{k0}, \frac{d}{dt} B(t) \right. \tag{8}$$

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

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

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

  #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<18,0.001,t<40,k2a,t<100,Lag(t,[40,80,100],[k2a,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,`3c.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],legendstyle=[font=[roman,15]]
): fdisplay(cat(Region,`3c`),%);
```

$$\beta := (t, k2a, k2b, k2c) \mapsto \left\{ \left(-0.07500000002\cdot t + 0.0004166666668\cdot t^2 + 3.333333334\right)\cdot k2a + \left(-5. + 0.1750000000\cdot t - 0.001250000000\cdot t^2\right)\cdot k2 \right.$$

$$\begin{matrix} 0.001 \\ k2a \\ k2c \end{matrix}$$

$res := [t = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, A(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, B(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, C(t) = \mathbf{proc}(t)\ \ldots\ \mathbf{end\ proc}, Q(t) = \mathbf{proc}(t)$
$\ldots$
end proc]

[13.44258404, 62802.67494, 0.1012133281, 0.1111242458, 0.2115507857, 0.1595470238, 0.08751331813, 0.08130220975, 0.07749483653, 0.1277152111, 0.007412379613, 0.01037824493, 0.0236434147, 0.0006037801923]

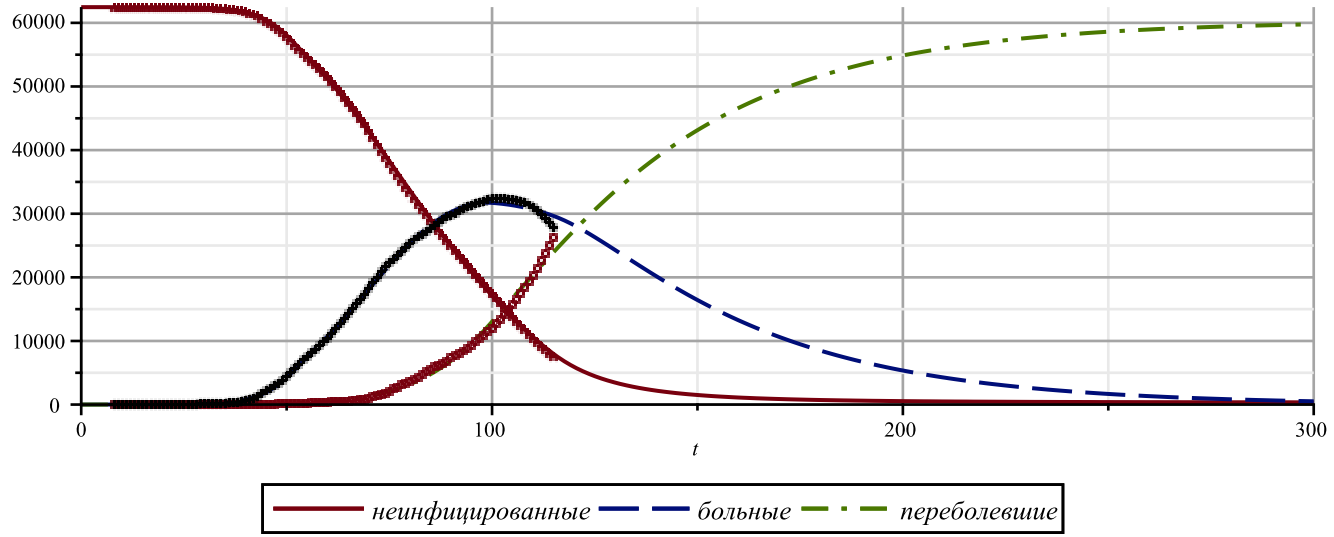
6540.24922696382

6540.24922696382
6514.39646472438
6504.73977536819
6500.63997791507
6497.13965922340
6494.79548185626
6491.99939655040
6490.34764042584
6487.42438261371
6485.48963220800
6472.90171250359
6463.09681253949
6438.95535228891
6433.18423900971
6428.39102323441
6425.75685755777
6423.59982216689
6422.00606602268
6420.12754268654
6418.82953784647
6417.28381385297
6415.78191814709
6410.56729555532
6405.39522910533
6404.51018455419
6403.37727533264
6402.86905877495

$val := [13.4846484991988, 62475.3056039865, 0.101588243810236, 0.111681085884875, 0.212273943769069, 0.157013723139909, 0.0865036190301633, 0.0812114241836506, 0.0771971808293624, 0.128032564036750, 0.00736171705530521, 0.0103840854353630, 0.0235902660839014, 0.000602486682783757]$

6402.86905877495

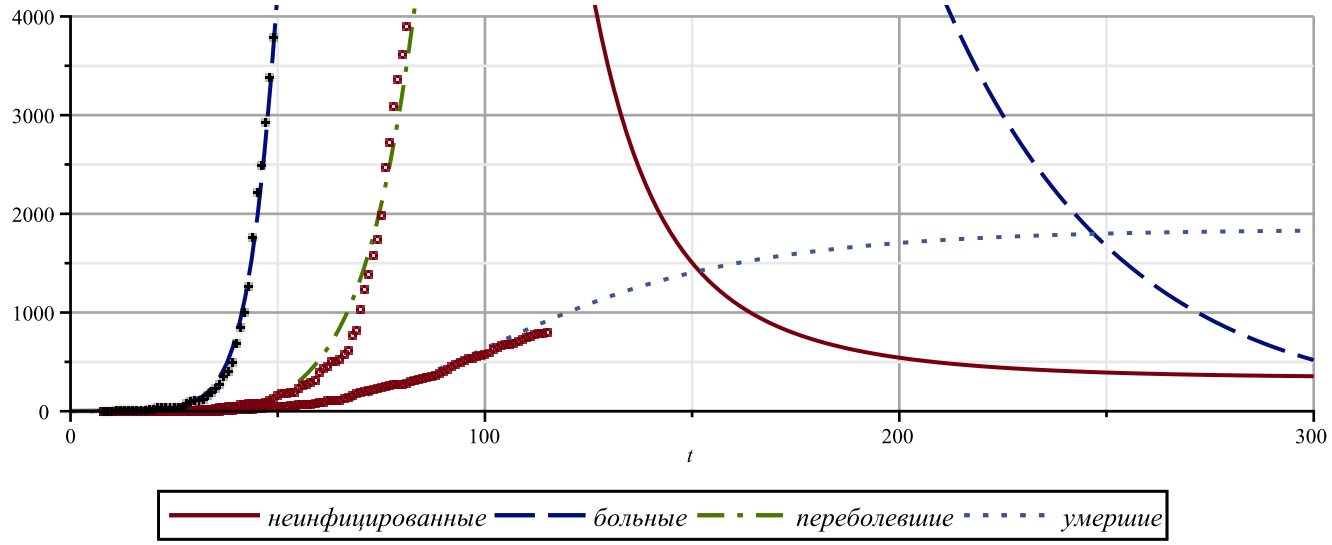
Mosobl3c.jpg



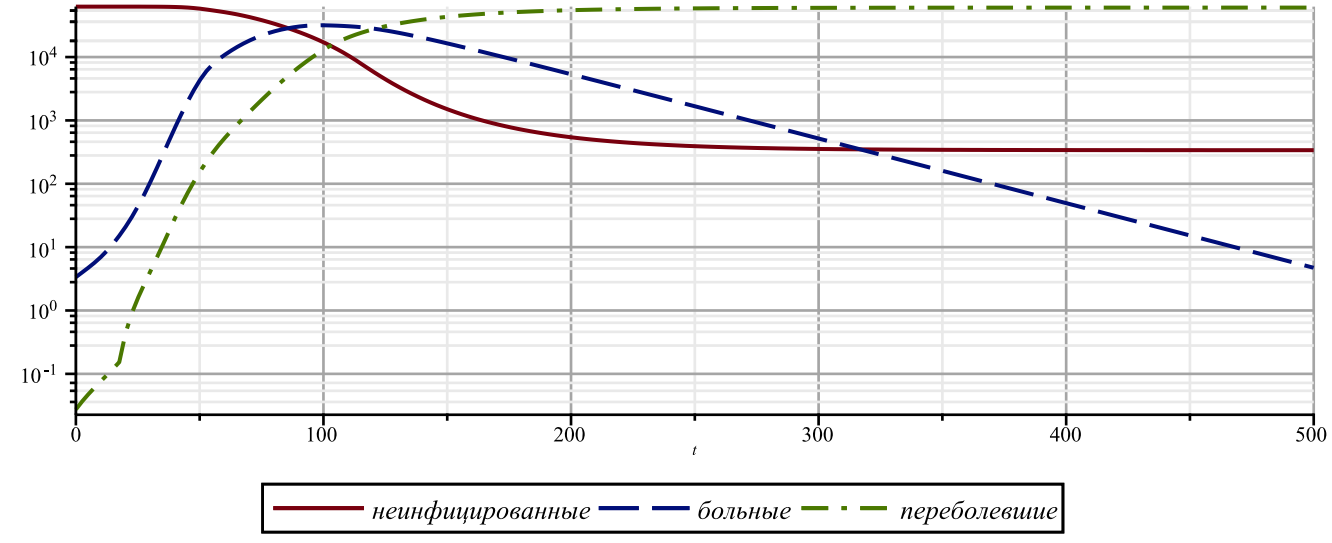

```
> val;
```

[13.4846484991988, 62475.3056039865, 0.101588243810236, 0.111681085884875, 0.212273943769069, 0.157013723139909, (9
0.0865036190301633, 0.0812114241836506, 0.0771971808293624, 0.128032564036750, 0.00736171705530521, 0.0103840854353630,
0.0235902660839014, 0.000602486682783757]

```
> display(
   plot(map(q->q(t),v), t = 0 . . 3 0 0 , l e g e n d = [ ` ` , ` ` , ` ` , ` `                                    ],
    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..4000]
  );
```



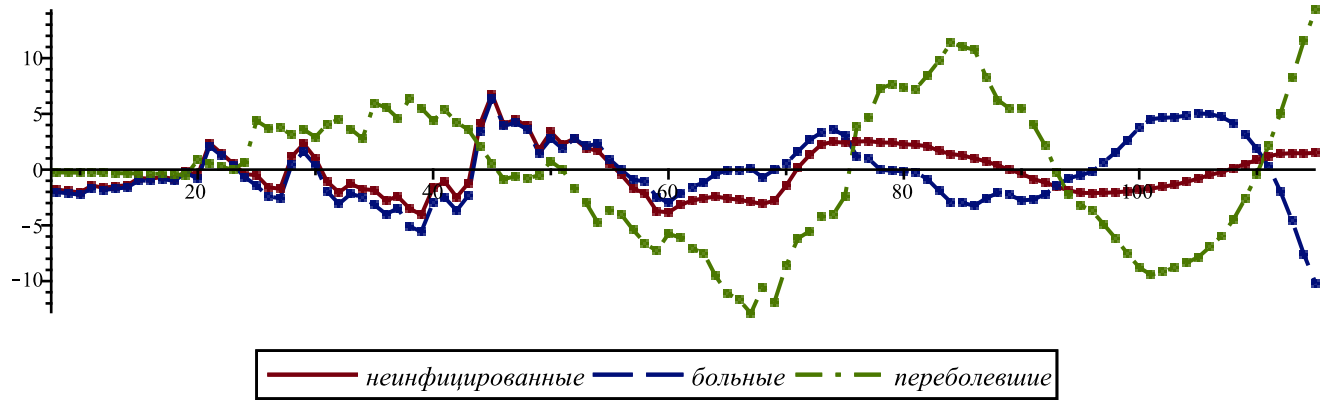

```
> logplot(map(q->q(t),v[1..3]), t=0..500, legend=[``,``,``],
  linestyle=[solid,dash,dashdot],gridlines=true,size=[1000,400],legendstyle=[font=[roman,15]]);
```




```
> display(
   plot([
    [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
    [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
```

```
  [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
 ],linestyle=[solid,dash,dashdot],l e g e n d = [ ` ` , ` ` , ` ` ]                    ),
 plot([
  [[i,(T[i-dd]-(K_-A(i)))/sigma(K_-A(i))] $ i=1+dd..dd+nops(T)],
  [[i,(T2[i-dd]-(B(i)))/sigma(B(i))] $ i=1+dd..dd+nops(T)],
  [[i,(T1[i-dd]-(C(i)))/sigma(C(i))] $ i=1+dd..dd+nops(T)]
 ],style=point,symbolsize=8,symbol=solidcircle),
 size=[1000,300],legendstyle=[font=[roman,15]]
): fdisplay(cat(Region,`3c-dev`),%);
```

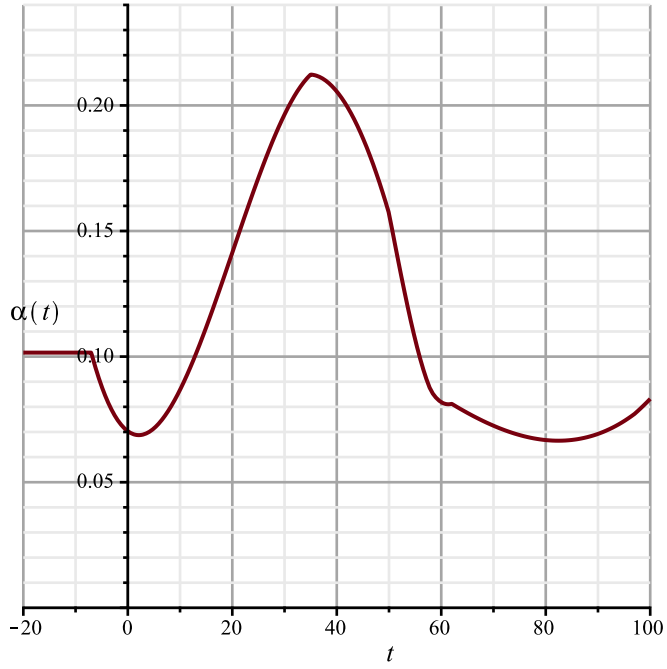
Mosobl3c-dev.jpg



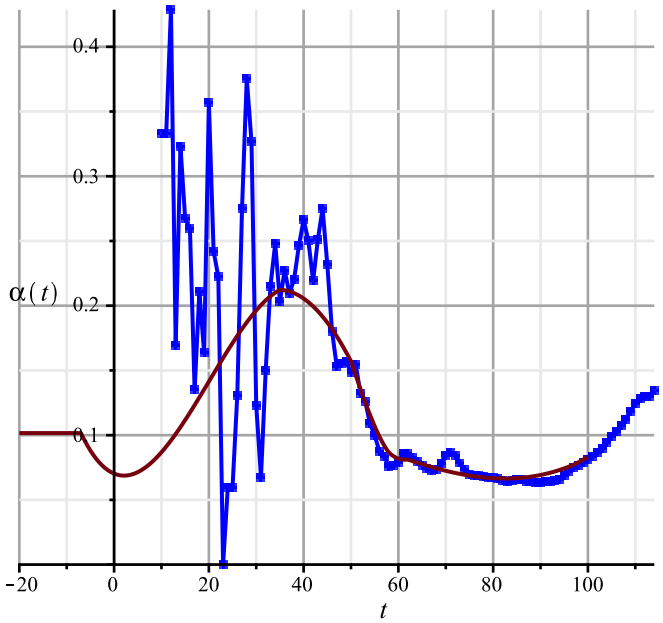

```
> [seq([i,(
  (T[i-dd]-T[i-dd-1]) /(T2[i-dd]+T2[i-dd-1]) /((1-T[i-dd]/K_)+(1-T[i-dd-1]/K_))
 )*4],i=1+dd+1..nops(T)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
 Palpha:=display(plot([%],color=blue),plot([%],style=point,symbolsize=8,symbol=solidcircle,color=
 blue)):
 #display(%,gridlines=true,labels=['t','alpha(t)'],labelfont=[roman,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,`3c-zar`),%); display([Palpha,%],t i t l e = `   `                ,titlefont=
 [roman,20]);
```

$$\begin{cases} 0.101588243810236 & t < -7. \\ -6.27705366039718\ 10^{-6}\ t^3 + 0.000378743720065812\ t^2 - 0.00151036214322235\ t + 0.0703042371057076 & t < 35. \\ 6.03002590494697\ 10^{-7}\ t^3 - 0.000309261902713840\ t^2 + 0.0193018079504592\ t - 0.110297238946187 & t < 50. \\ 0.000313799528517988\ t^3 - 0.00471036580242839\ t^2 + 0.224891836166461\ t - 3.23415769372680 & t < 58. \\ -0.000126221851821180\ t^3 + 0.00276999767210657\ t^2 - 0.197352681073602\ t + 4.67742672945581 & t < 62. \\ 4.29247182985156\ 10^{-7}\ t^3 - 0.000621631511551986\ t^2 + 0.00149894275450570\ t + 0.124930499642958 & t < 97. \\ 0.000554505779072480\ t^2 - 0.00893133454643109\ t + 0.421802145194817 & t < 115. \\ 0.128032564036750 & 115. \le t \end{cases}$$

Mosobl3c-zar.jpg



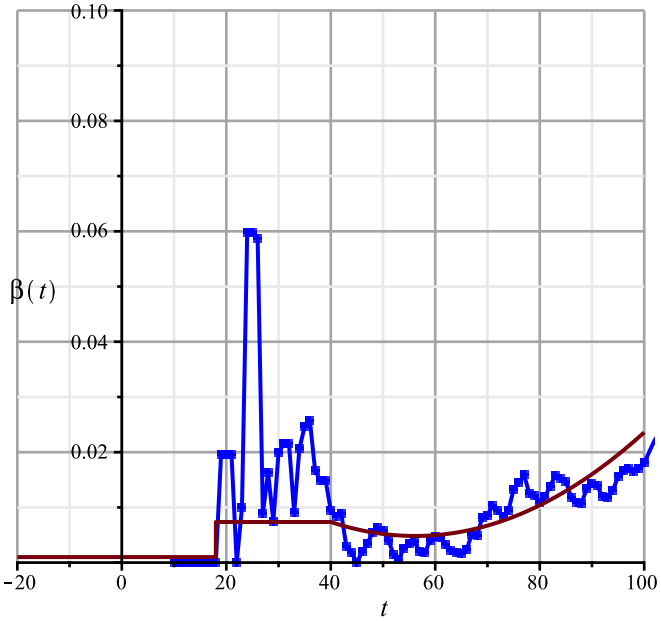
Коэффициент заражения



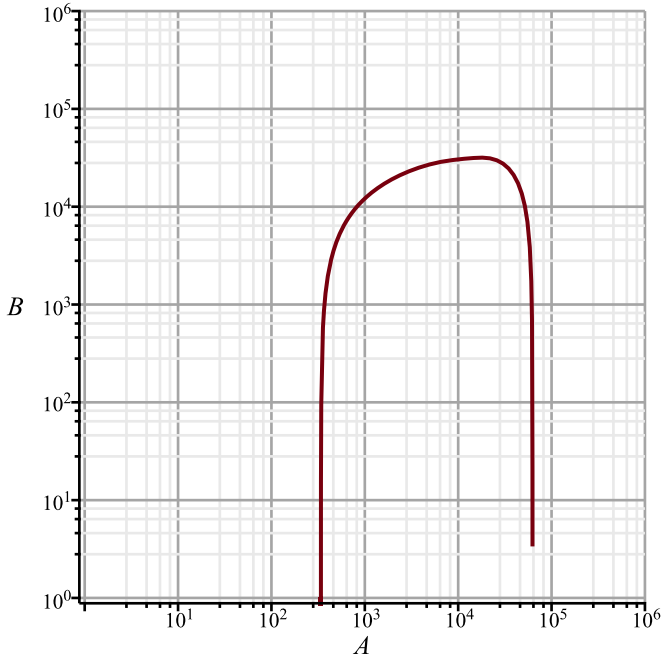

```
> [seq([i,(
   (T1[i-dd]-T1[i-dd-1]) /(T2[i-dd]+T2[i-dd-1])
  )*2],i=1+dd+1..nops(T1)+dd)]: [seq([%[i][1],(%[i-1][2]+%[i][2]+%[i+1][2])/3],i=2..nops(%)-1)]:
  Pbeta:=display(plot([%],color=blue),plot([%],style=point,symbolsize=8,symbol=solidcircle,color=
  blue)):

  subs(corr(par,val),beta(t,k2a,k2b,k2c));
  plot(%,t=-20..100,gridlines=true,labels=['t',''beta(t)''],labelfont=[roman,15]):
  display([Pbeta,%],t i t l e = `   `                    ,titlefont=[roman,20],view=[-20..100,0..0.1]);
```

$$\begin{cases} 0.001 & t < 18. \\ 0.00736171705530521 & t < 40. \\ -0.00109394043649674\, t + 9.74583038700451\, 10^{-6}\, t^2 + 0.0355260059107106 & t < 100. \\ 0.0235902660839014 & 100. \le t \end{cases}$$

Коэффициент выздоровления




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




```
> 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});
```

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

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

$$\left[A = \frac{k0\,\left(k2c + k3\right)}{-0.024258761\,k1x6 + 0.90476191\,k1x7 + 0.119496860\,k1x8}, B = 0.\right]$$

$$J := \begin{bmatrix} P_{01} - \dfrac{C\,P_{01}\,P_{12} + k0\,P_{01}\,P_{20} + k0\,P_{01}\,P_{23} - k0\,P_{10}\,P_{20} - k0\,P_{10}\,P_{23}}{\left(P_{23} + P_{20}\right) k0} - P_{10} & -P_{23} - P_{20} \\ \dfrac{C\,P_{01}\,P_{12} + k0\,P_{01}\,P_{20} + k0\,P_{01}\,P_{23} - k0\,P_{10}\,P_{20} - k0\,P_{10}\,P_{23}}{\left(P_{23} + P_{20}\right) k0} & 0 \end{bmatrix}$$

$$J := \begin{bmatrix} 0. & -0.0241927527666851 \\ 0. & 0. \end{bmatrix}$$

$$\lambda^2$$

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

(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):
```

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

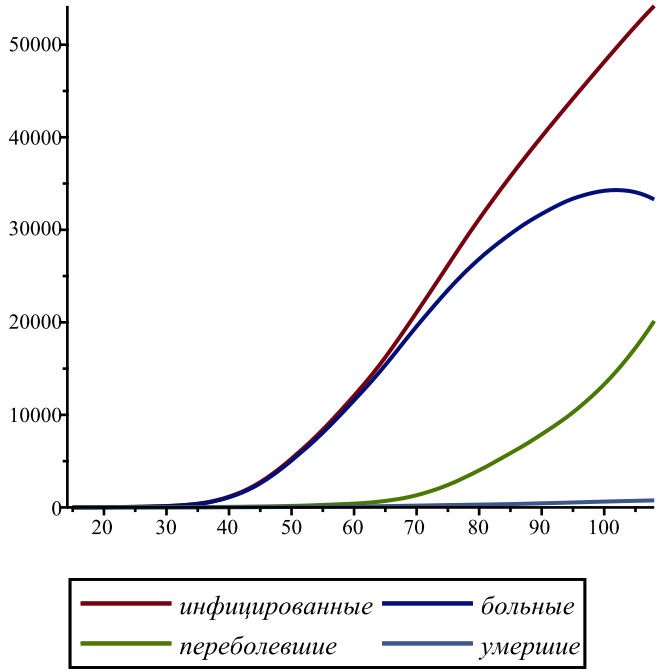
$d0 = 13.4846484991988,\ k0 = 62475.3056039865,\ k1x1 = 0.101588243810236,\ k1x2 = 0.111681085884875,\ k1x3 = 0.212273943769069,\ k1x4 = 0.157013723139909,\ k1x5 = 0.0865036190301633,\ k1x6 = 0.0812114241836506,\ k1x7 = 0.0771971808293624,\ k1x8 = 0.128032564036750,\ k2a = 0.00736171705530521,\ k2b = 0.0103840854353630,\ k2c = 0.0235902660839014,\ k3 = 0.000602486682783757$

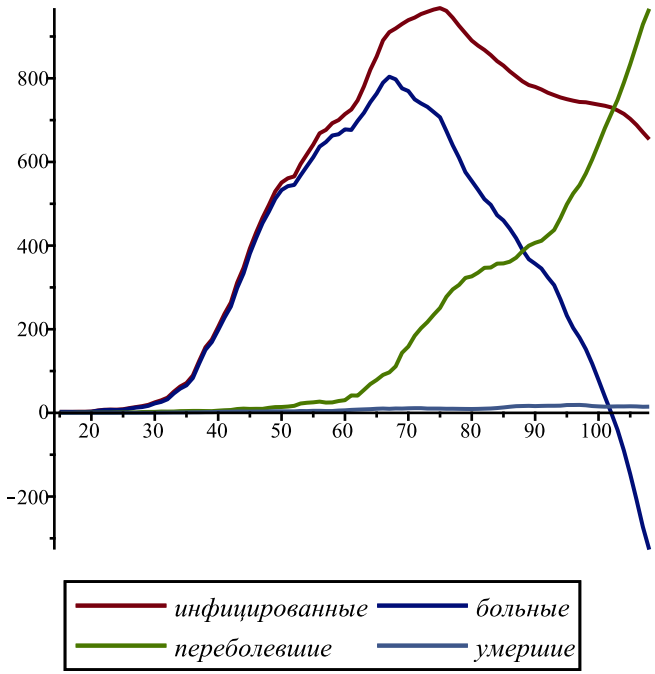
$$\left[\frac{\partial}{\partial t}\ A = -\frac{B\,k1\,A}{k0},\ \frac{\partial}{\partial t}\ B = \frac{B\,k1\,A}{k0} - k2\,B - k3\,B,\ \frac{\partial}{\partial t}\ C = k2\,B - C\,k4,\ \frac{\partial}{\partial t}\ Q = k3\,B\right]$$

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

```
> k:=7;
  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]]
  );
```

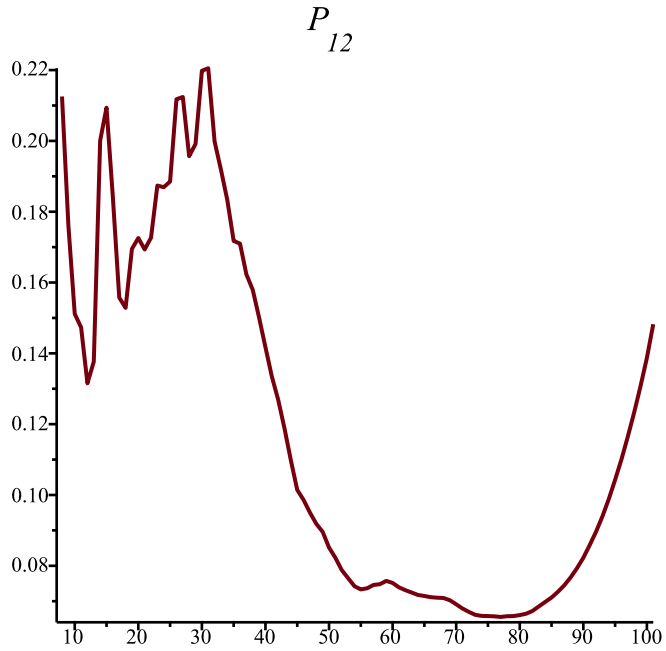
$k := 7$

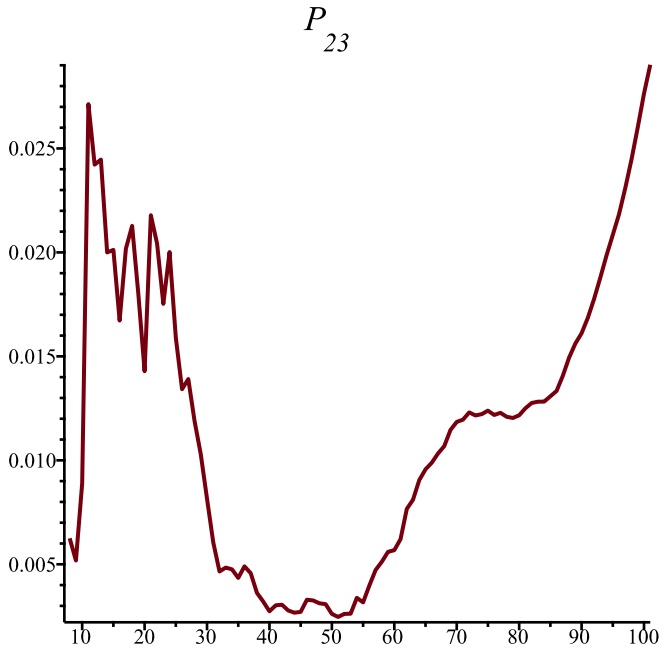


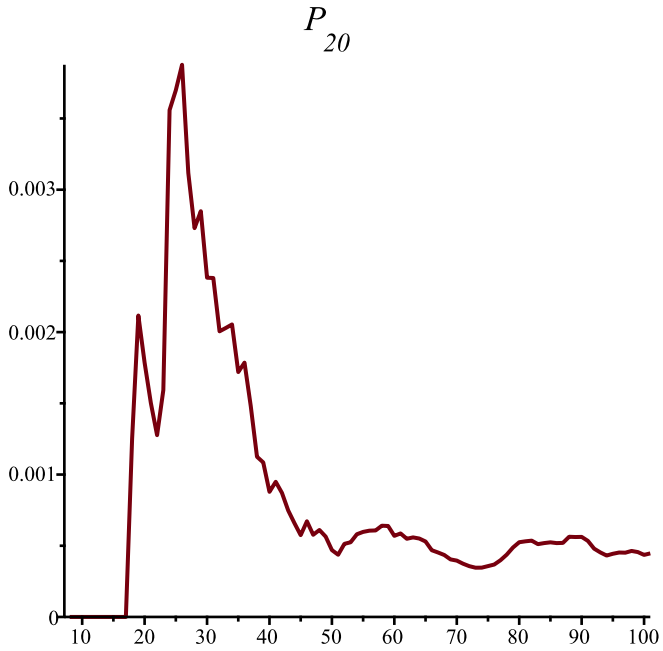



```
> k:=0;

  [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}
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
10
20
30
40
50
60
70
80
90
100


P_{23}
0.025
0.020
0.015
0.010
0.005
10
20
30
40
50
60
70
80
90
100


P_{20}
0.003
0.002
0.001
0
10
20
30
40
50
60
70
80
90
100