STOCHASTIC MODELING OF LAKE VAN WATER LEVEL TIME SERIES WITH JUMPS AND MULTIPLE TRENDS

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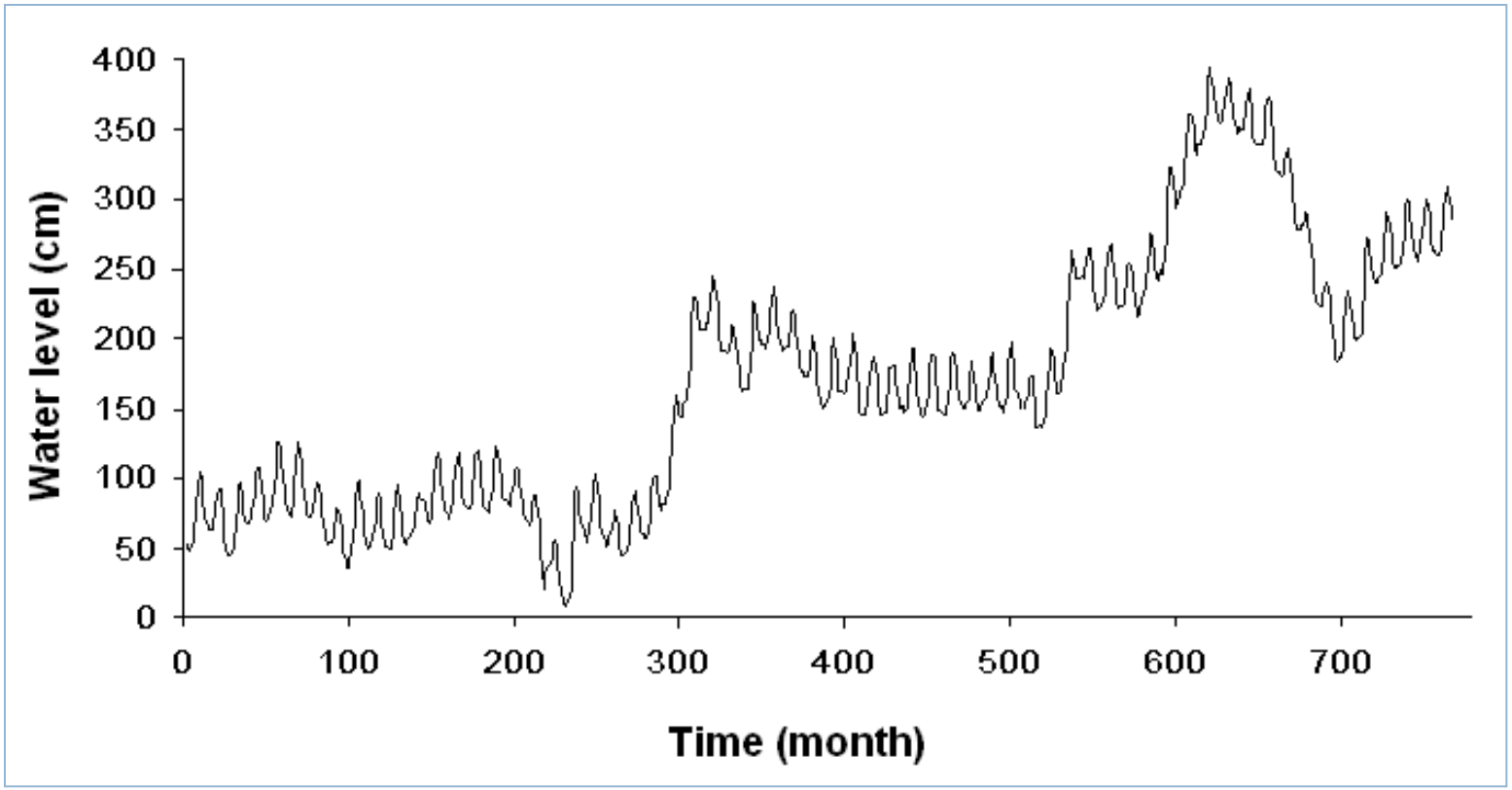
STUDY AREA

- surface area ~3528km^2
  drainage area ~ 12000 km^2
- elevation above the sea level is 1650 m

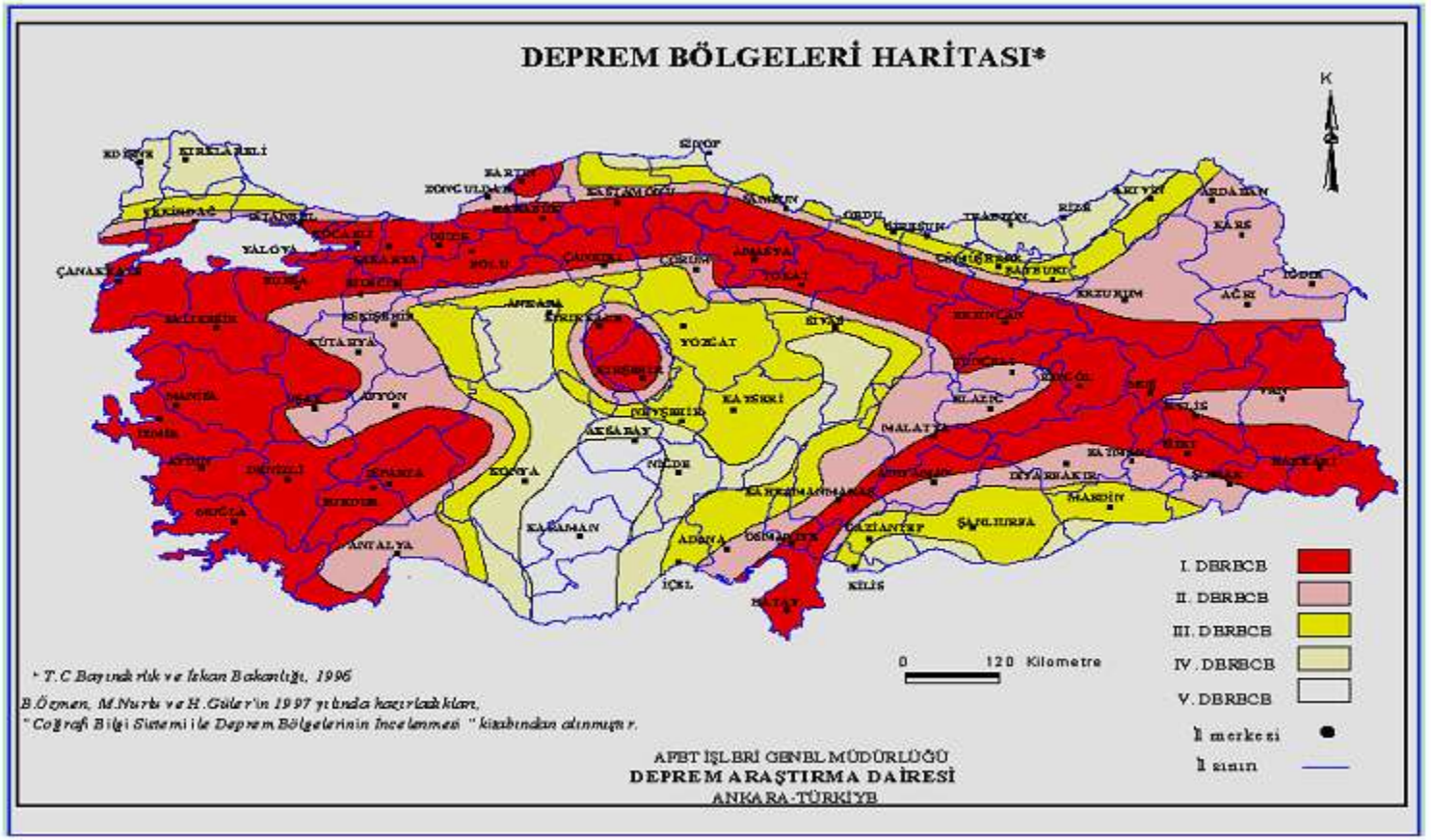
  the deepest point is 457 m
- high salinity, no drinking or irrigation

- fed by rainfall, small rivers and melts water of ice
- yearly 50-60 cm fluctuation in lake level
- no natural outlet, water discharges by only evaporation

DATA

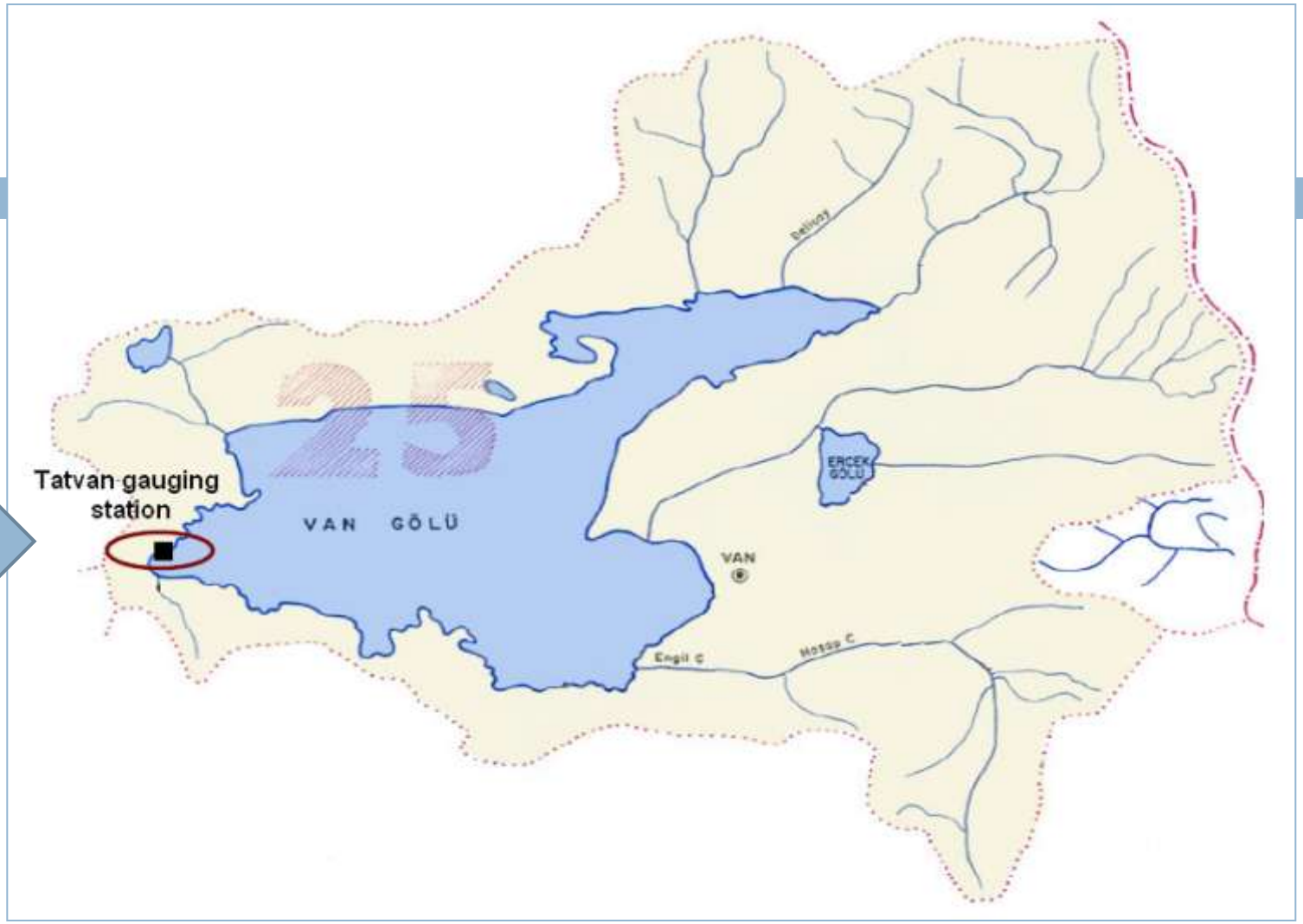


- Monthly lake water level data from 1943 to 2007 (768-month = 64-year data) from Tatvan gauging station

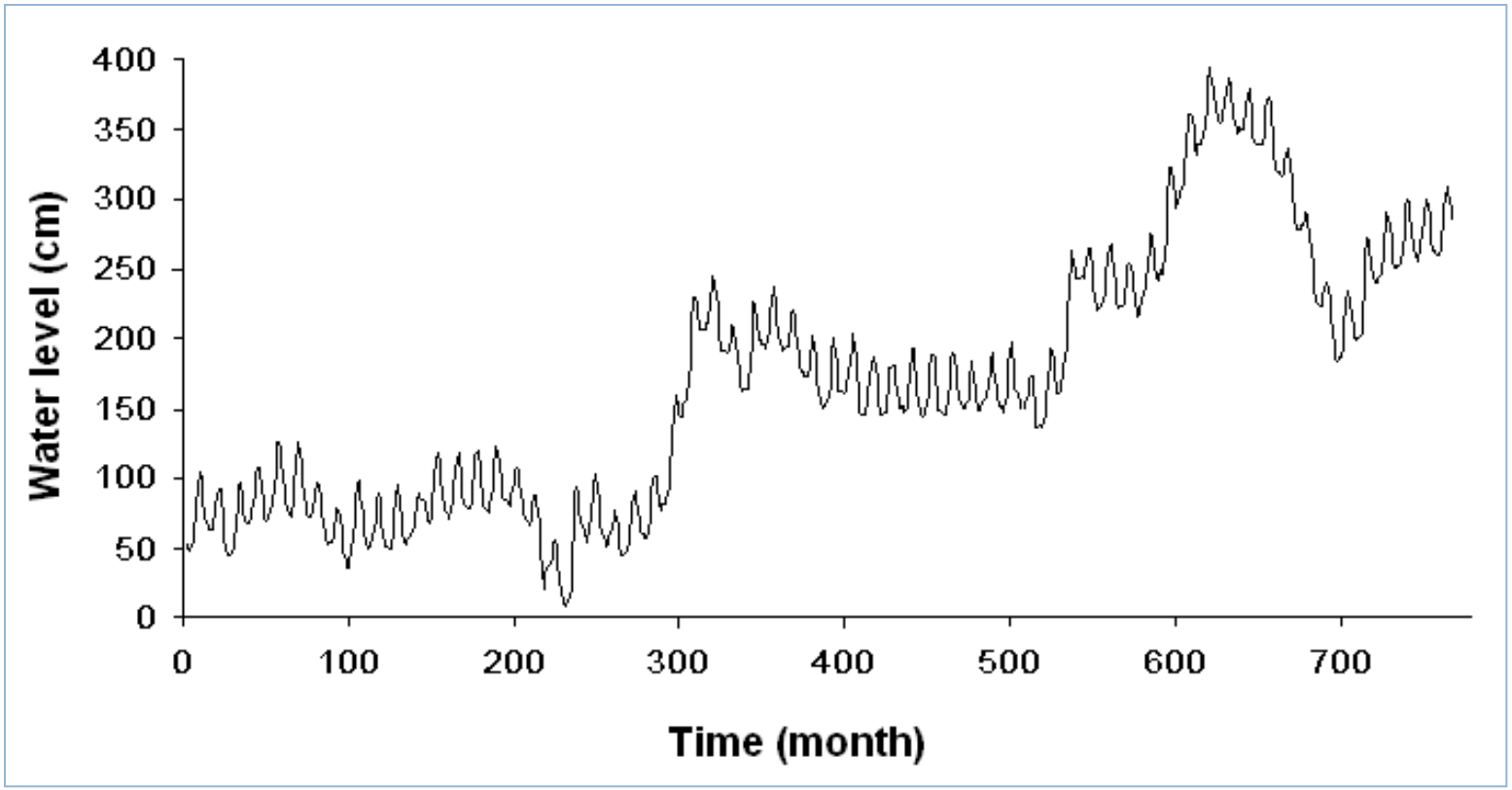

DEPREM BÖLGELERİ HARİTASI*
K
I. DERECE
II. DERECE
III. DERECE
IV. DERECE
V. DERECE
İl merkezi
İl sınırı
0 120 Kilometre
* T.C Bayındırlık ve İskan Bakanlığı, 1996
B.Özmen, M.Nurlu ve H.Güler'in 1997 yılında hazırladıkları,
"Coğrafi Bilgi Sistemi ile Deprem Bölgelerinin İncelenmesi" kitabından alınmıştır.
AFET İŞLERİ GENEL MÜDÜRLÜĞÜ
DEPREM ARAŞTIRMA DAİRESİ
ANKARA-TÜRKİYE

Lake Van Monster

DATA


Tatvan gauging station
VAN GÖLÜ
ERCEK GÖLÜ
VAN
Engil Ç
Hoşap Ç

DATA



- Monthly lake water level data from 1943 to 2007 (768-month = 64-year data) from Tatvan gauging station

MODEL

- AR(p) $y_t = \phi_1 y_{t-1} + ... + \phi_p y_{t-p} + \varepsilon_t$
- MA(q) $y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$
- ARMA(p,q)

$$y_t = \phi_1 y_{t-1} + ... + \phi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$$

in this study

AR(2)

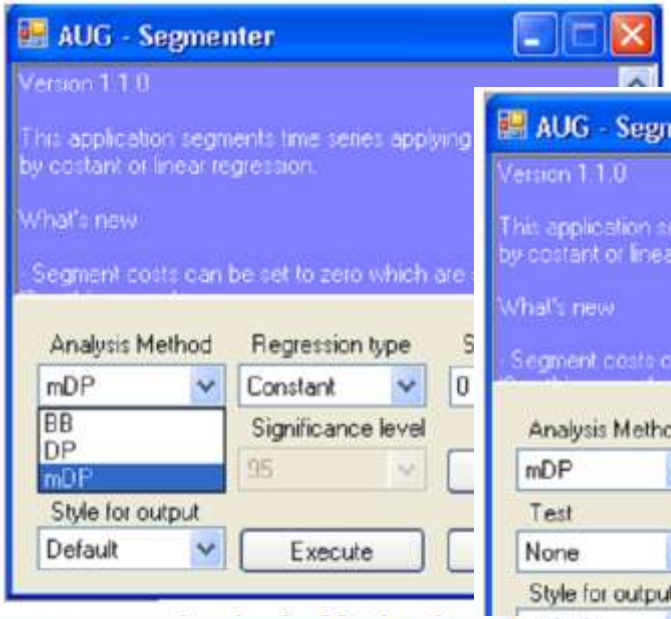
$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \varepsilon_t$$

$$\phi_1 = \frac{\rho_1 - \rho_1 \rho_2}{1 - \rho_1^2}, \phi_2 = \frac{\rho_2 - \rho_1^2}{1 - \rho_1^2}$$

$$\sigma_\varepsilon^2 = 1 - R^2, R^2 = \frac{\rho_1^2 + \rho_2^2 - 2\rho_1^2 \rho_2}{1 - \rho_1^2}$$

SEGMENTER

Regression Types



Program Interface

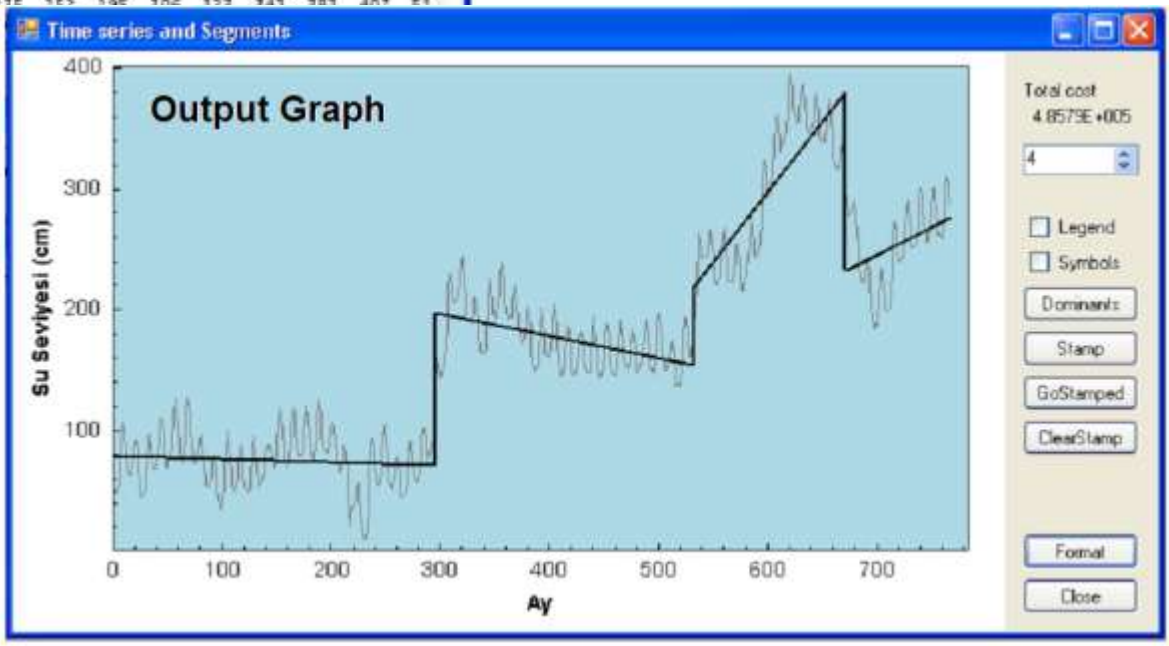
Tests

SEGMENTER

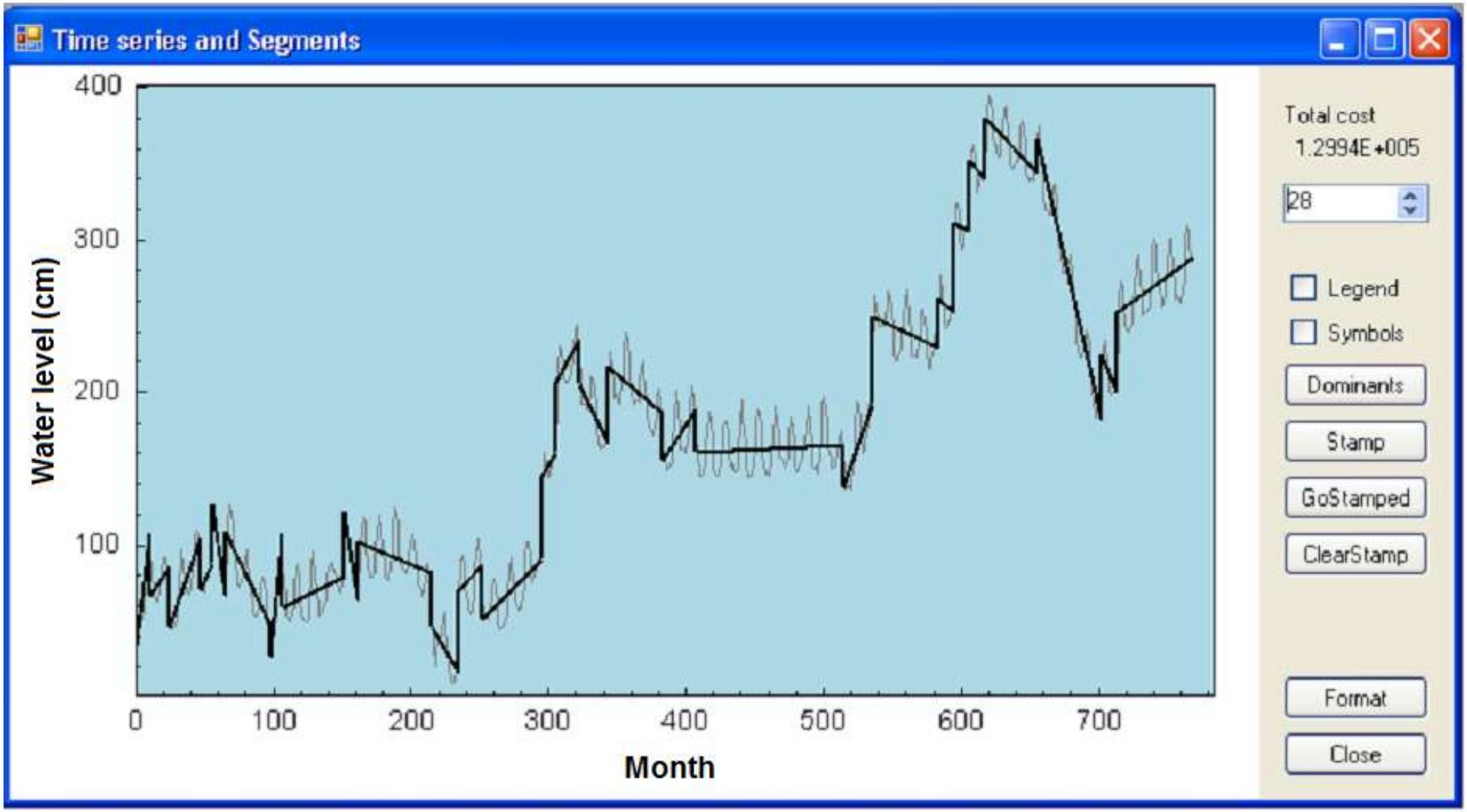
Reporter - ssd.txt

Report

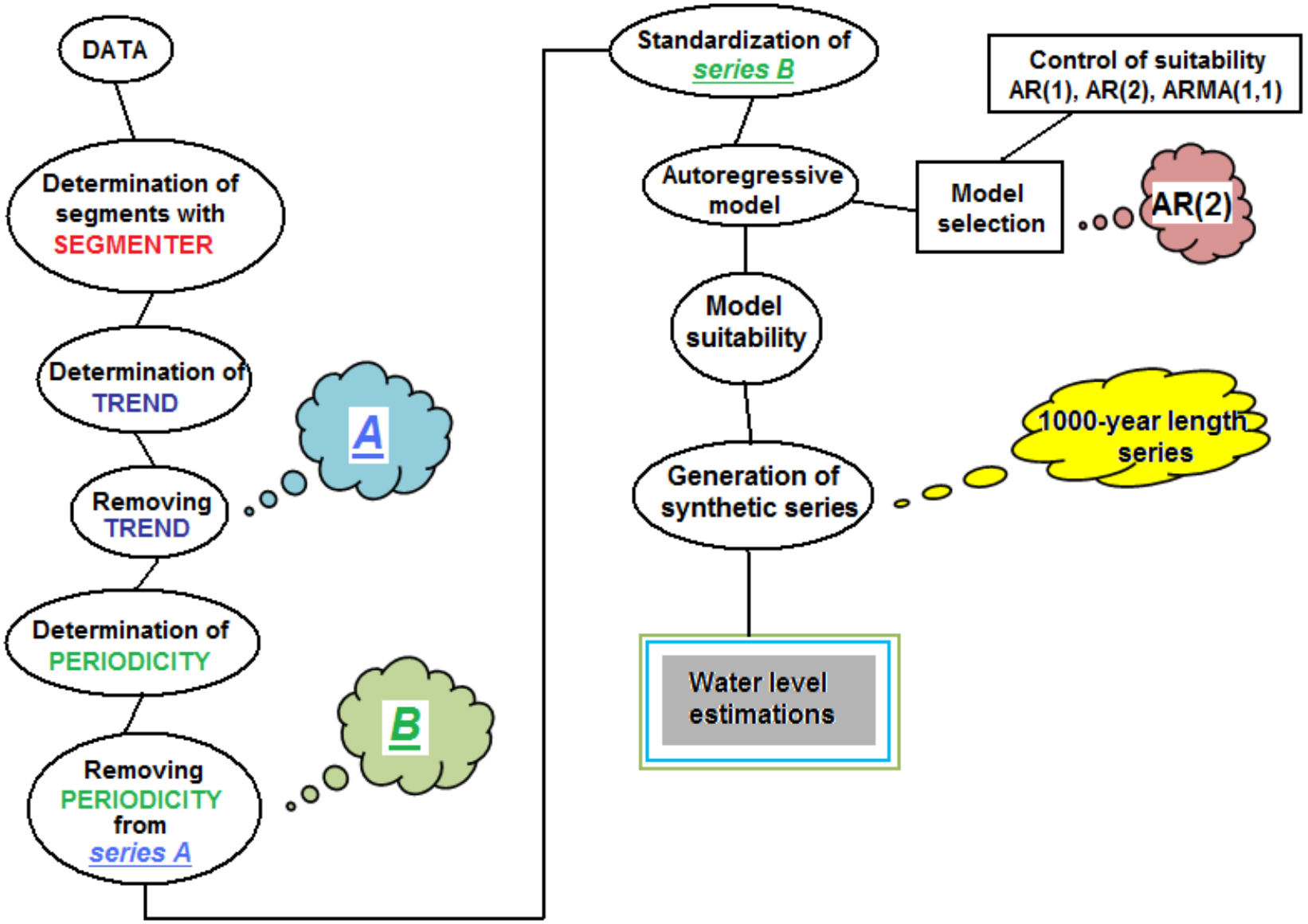
```
File name          ssd.txt
Number of items    768
Average            1.6867E+002
Regression         Linear
Max order          384
Duration           00:00:00.6718750
The best order     383 (Scheffe)
Significance level   N95

Order          Cost     Scheffe=383     Change points
    1  1.798124E+006             NAN  768
    2  1.186015E+006  0.000000E+000  595  768
    3  7.977994E+005  0.000000E+000  295  595  768
    4  4.857893E+005  0.000000E+000  295  533  671  768
    5  3.770375E+005  0.000000E+000  295  534  606  683  768
    6  3.360991E+005  0.000000E+000  295  534  595  645  703  768
    7  2.961857E+005  2.000000E+000  215  305  534  595  645  703  768
    8  2.672611E+005  0.000000E+000  215  295  323  534  595  645  703  768
    9  2.470725E+005  2.000000E+000   83  215  295  323  534  595  645  703  768
   10  2.301120E+005  2.000000E+000   83  215  295  323  372  535  595  645  703  768
   11  2.143588E+005  2.000000E+000   83  215  295  323  372  535  594  619  655  702  768
   12  1.989657E+005  2.000000E+000   83  187  235  294  323  372  535  594  619  655  702  768
   13  1.903469E+005  2.000000E+000   83  187  235  279  307  343  383  535  594  619  655  702  768
   14  1.818616E+005  2.000000E+000   83  187  235  279  307  343  383  535  594  619  655  702  714  768
   15  1.768311E+005  2.000000E+000   83  187  235  279  307  343  383  515  535  594  619  655  702  714  76
   16  1.718951E+005  2.000000E+000   83  187  235  252  295  307  343  383  515  535  594  619  655  702  71
   17  1.675196E+005  2.000000E+000   11   83  187  235  252  295  307  343  383  515  535  594  619  655  70
   18  1.631079E+005  2.000000E+000   11   55  101  187  235  252  295  307  343  383  515  535  594  619  65
   19  1.589933E+005  2.000000E+000   11   55  101  187  235  252  295  307  343  383  515  535  583  594  61
   20  1.550209E+005  2.000000E+000   11   55   66  101  187  235  252  295  307  343  383  515  535  583  59
   21  1.512907E+005  2.000000E+000   11   55   66  101  187  235  252  295  307  343  383  407  515  535  58
   22  1.477657E+005  2.000000E+000   11   55   66  102  139  203  235  252  295  307  343  383  407  515  53
   23  1.443053E+005  2.000000E+000   11   55   66  102  139  203
   24  1.412744E+005  2.000000E+000   11   55   66  102  127  139
   25  1.383355E+005  2.000000E+000   11   55   66   98  107  151
   26  1.354085E+005  2.000000E+000    7   31   55   66   98  107
   27  1.325849E+005  2.000000E+000    7   31   55   66   98  107
   28  1.299394E+005  2.000000E+000   11   24   47   55   66   98
   29  1.273125E+005  2.000000E+000   11   24   47   55   66   98
   30  1.247409E+005  2.000000E+000   11   24   47   55   66   98
   31  1.223148E+005  2.000000E+000   11   24   47   55   66   98
```



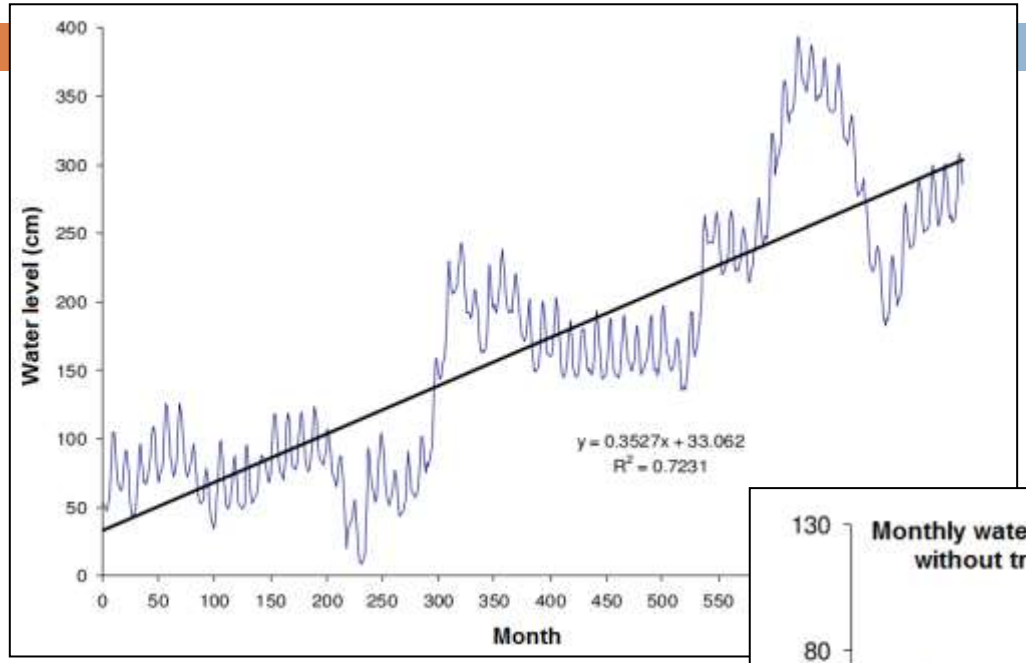
SEGMENTER

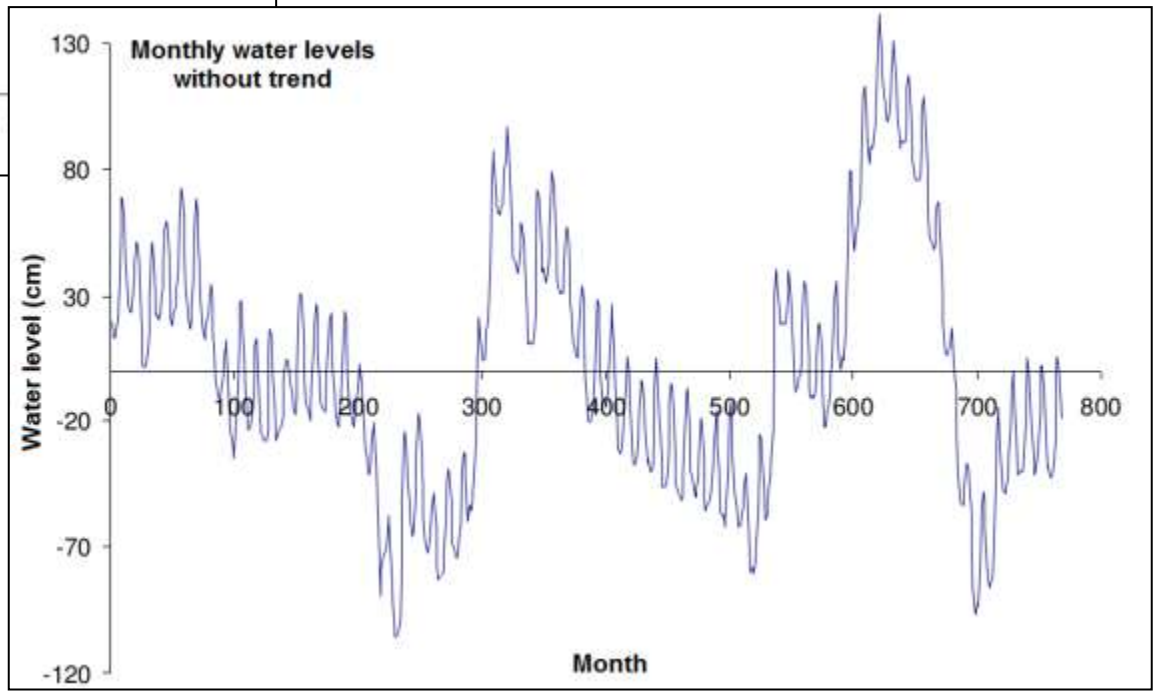

Time series and Segments
Water level (cm)
400
300
200
100
0
100
200
300
400
500
600
700
Month
Total cost
1.2994E+005
28
Legend
Symbols
Dominants
Stamp
GoStamped
ClearStamp
Format
Close

APPLICATION

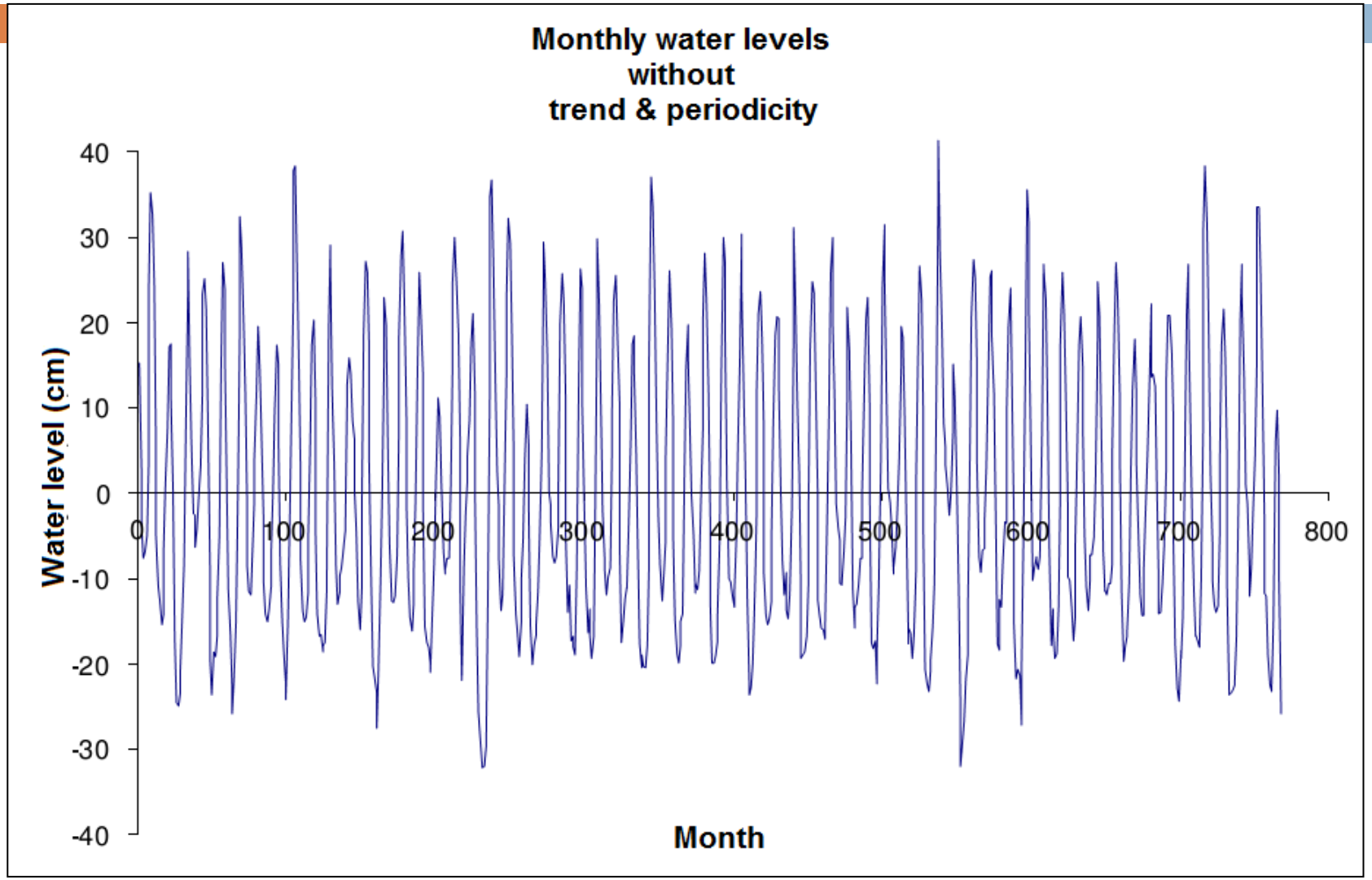


1-TREND LINE


Water level (cm)
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
400
450
500
550
Month
y = 0.3527x + 33.062
R² = 0.7231

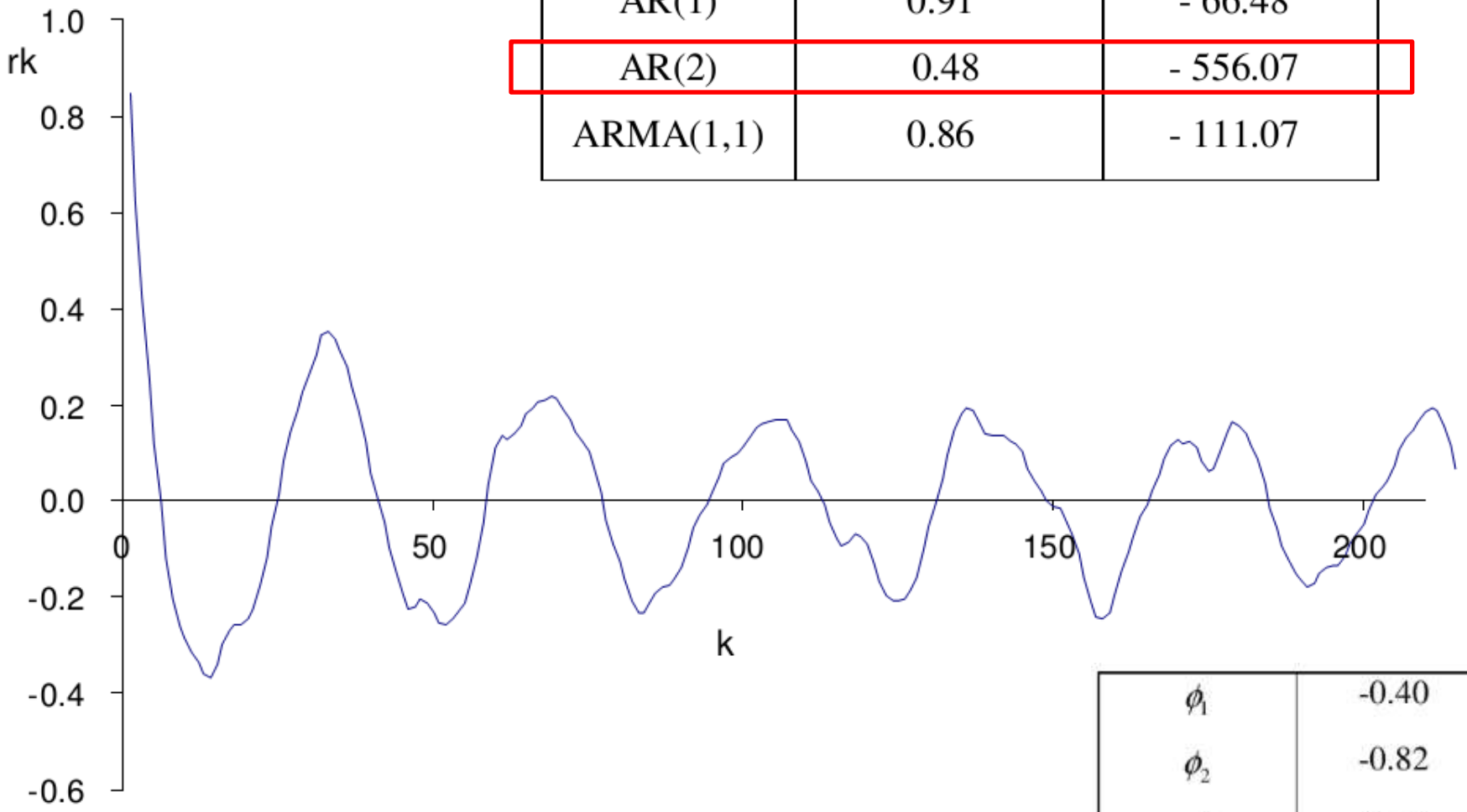

Monthly water levels without trend
Water level (cm)
130
80
30
-20
-70
-120
0
100
200
300
400
500
600
700
800
Month

1-TREND LINE


Monthly water levels
without
trend & periodicity
Water level (cm)
40
30
20
10
0
-10
-20
-30
-40
0
100
200
300
400
500
600
700
800
Month

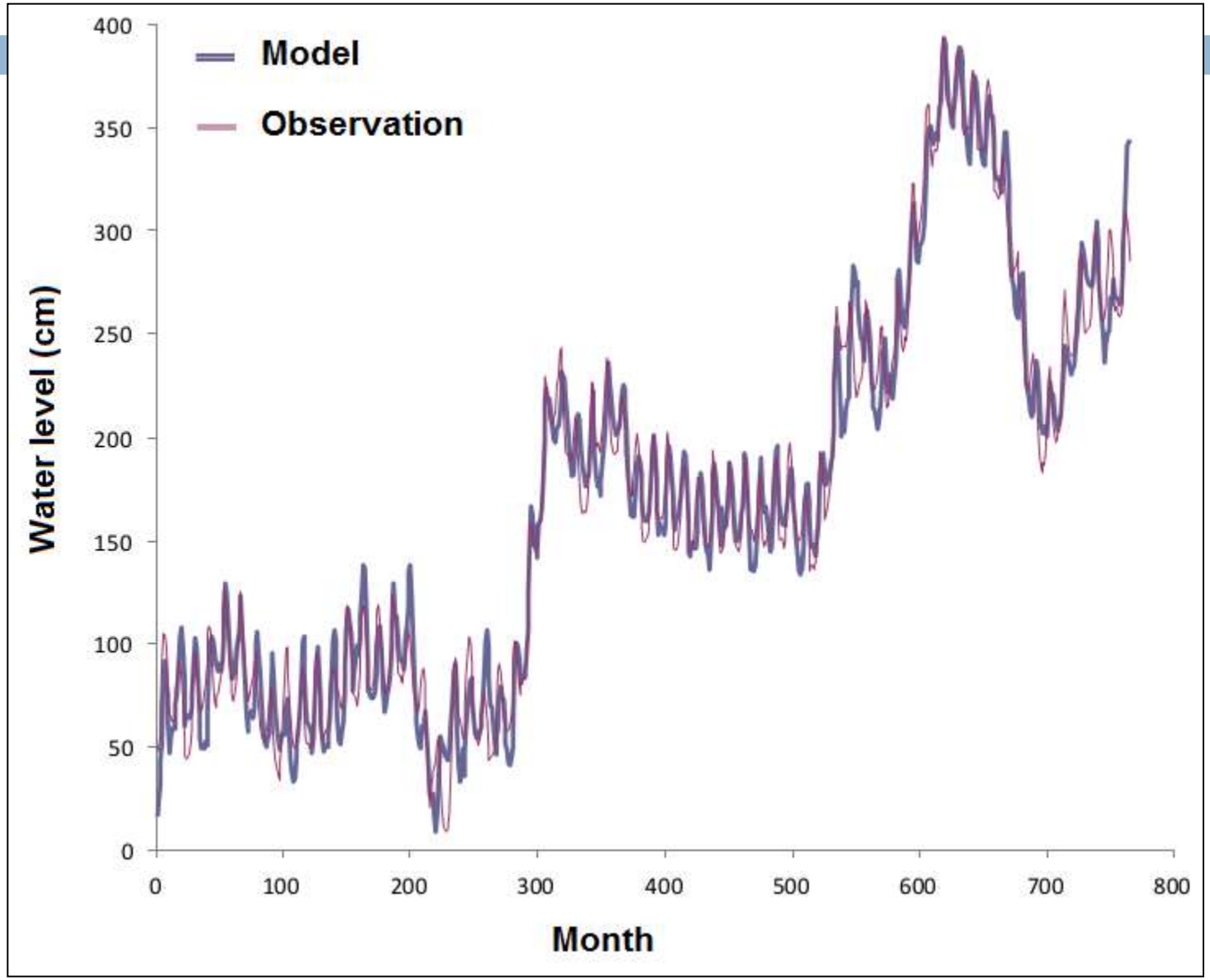
1-TREND LINE

Model	Variance, σ_ε^2	AIC
AR(1)	0.91	- 66.48
AR(2)	0.48	- 556.07
ARMA(1,1)	0.86	- 111.07

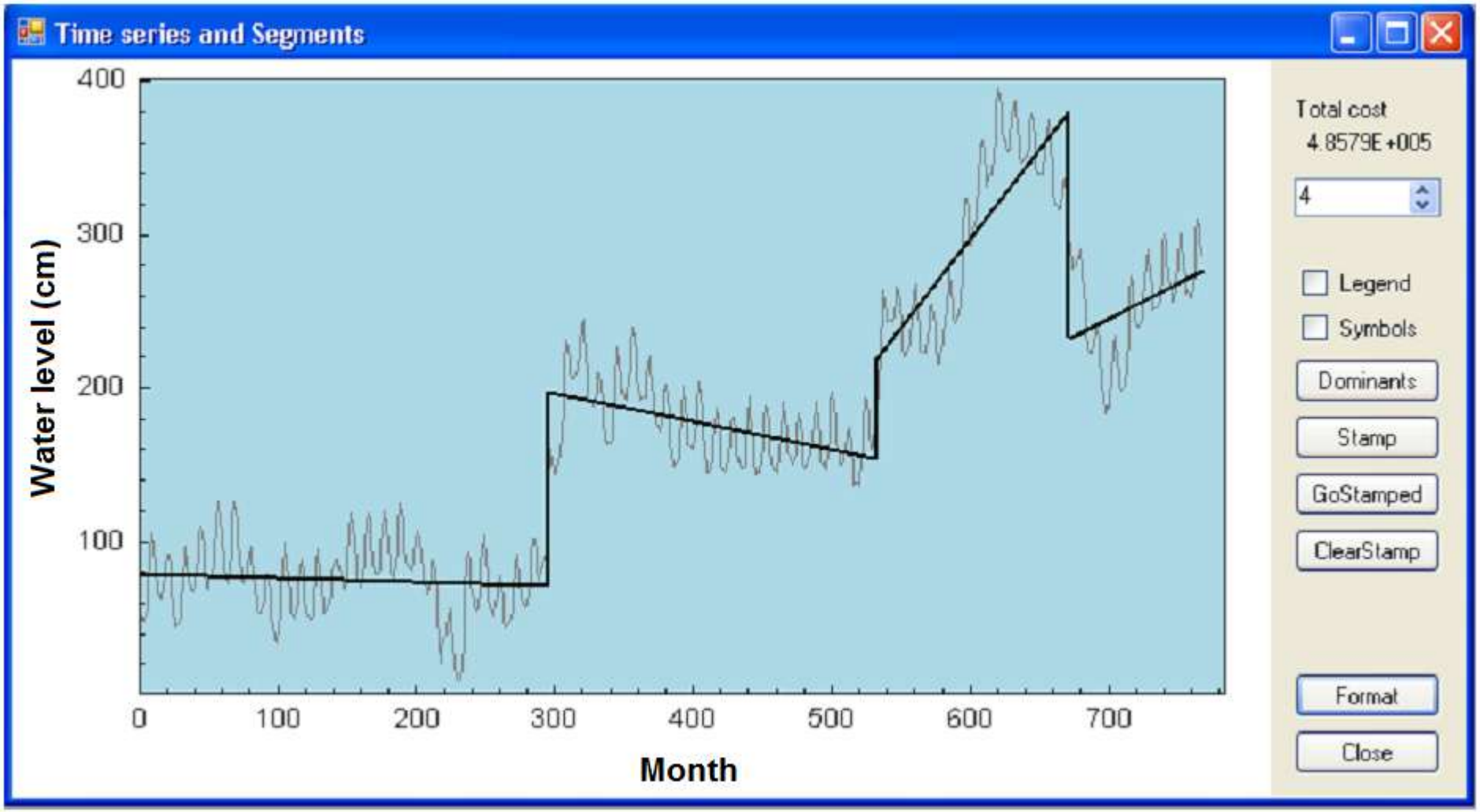


ϕ_1	-0.40
ϕ_2	-0.82
σ_ε^2	0.74

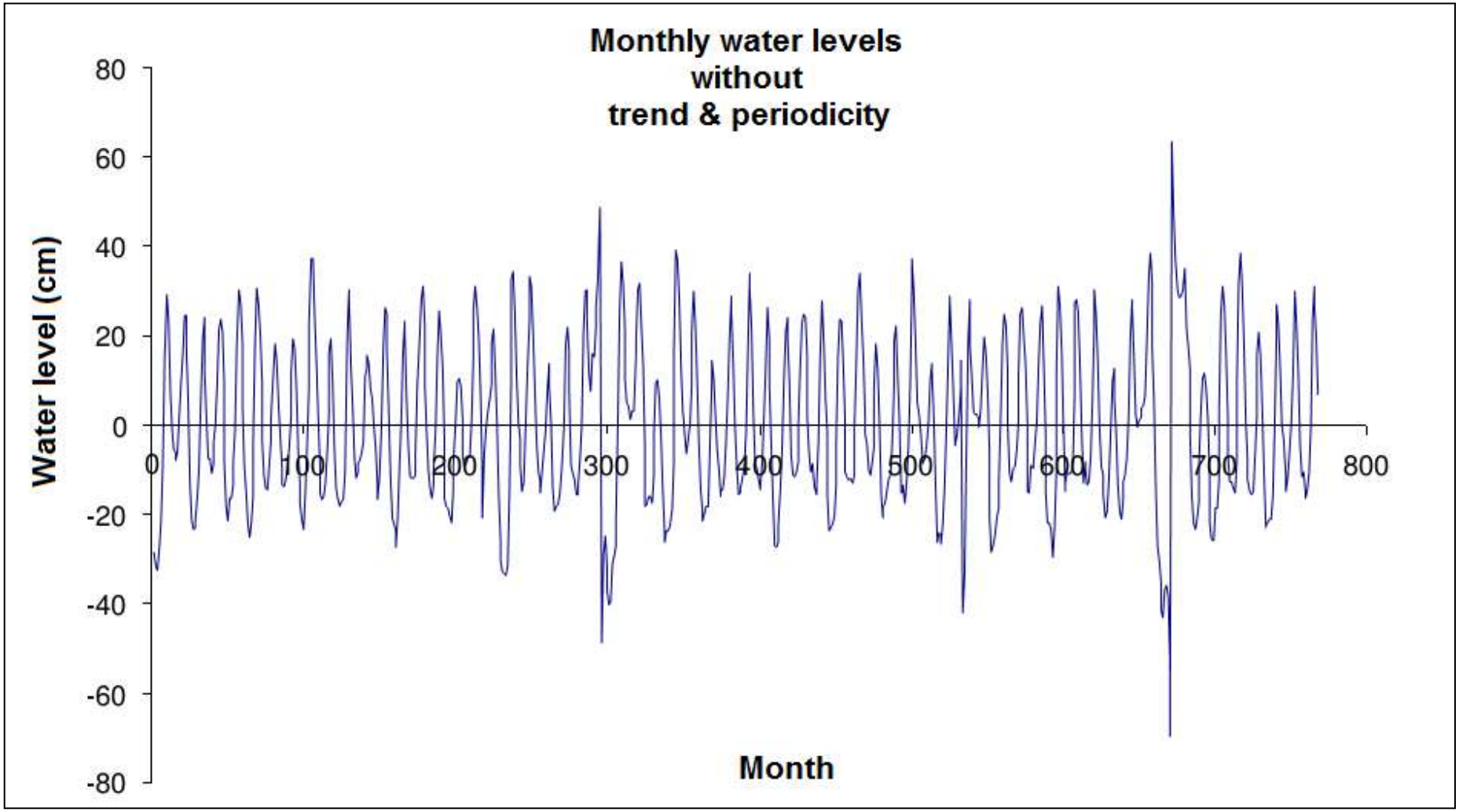
1-TREND LINE


Model
Observation
Water level (cm)
Month
0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
600
700
800

4-TREND LINE

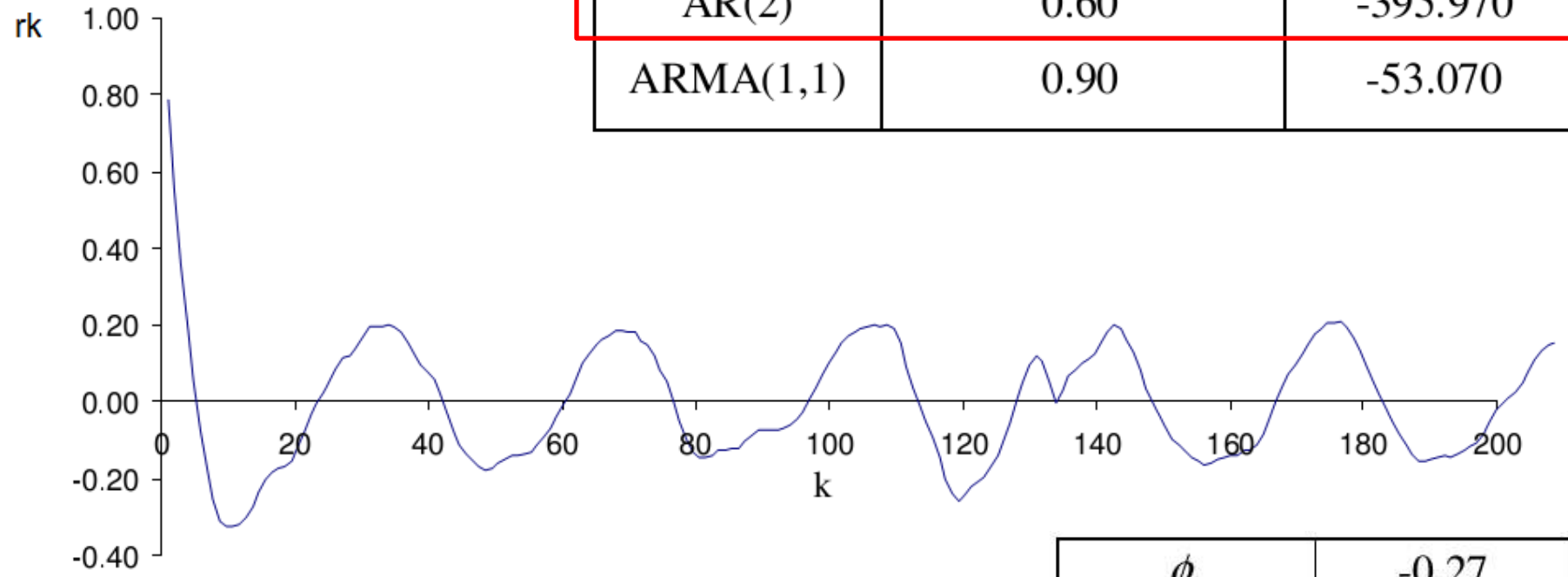

Time series and Segments
Water level (cm)
400
300
200
100
0
100
200
300
400
500
600
700
Month
Total cost
4.8579E+005
4
Legend
Symbols
Dominants
Stamp
GoStamped
ClearStamp
Format
Close

4-TREND LINE


Monthly water levels
without
trend & periodicity
Water level (cm)
80
60
40
20
0
-20
-40
-60
-80
0
100
200
300
400
500
600
700
800
Month

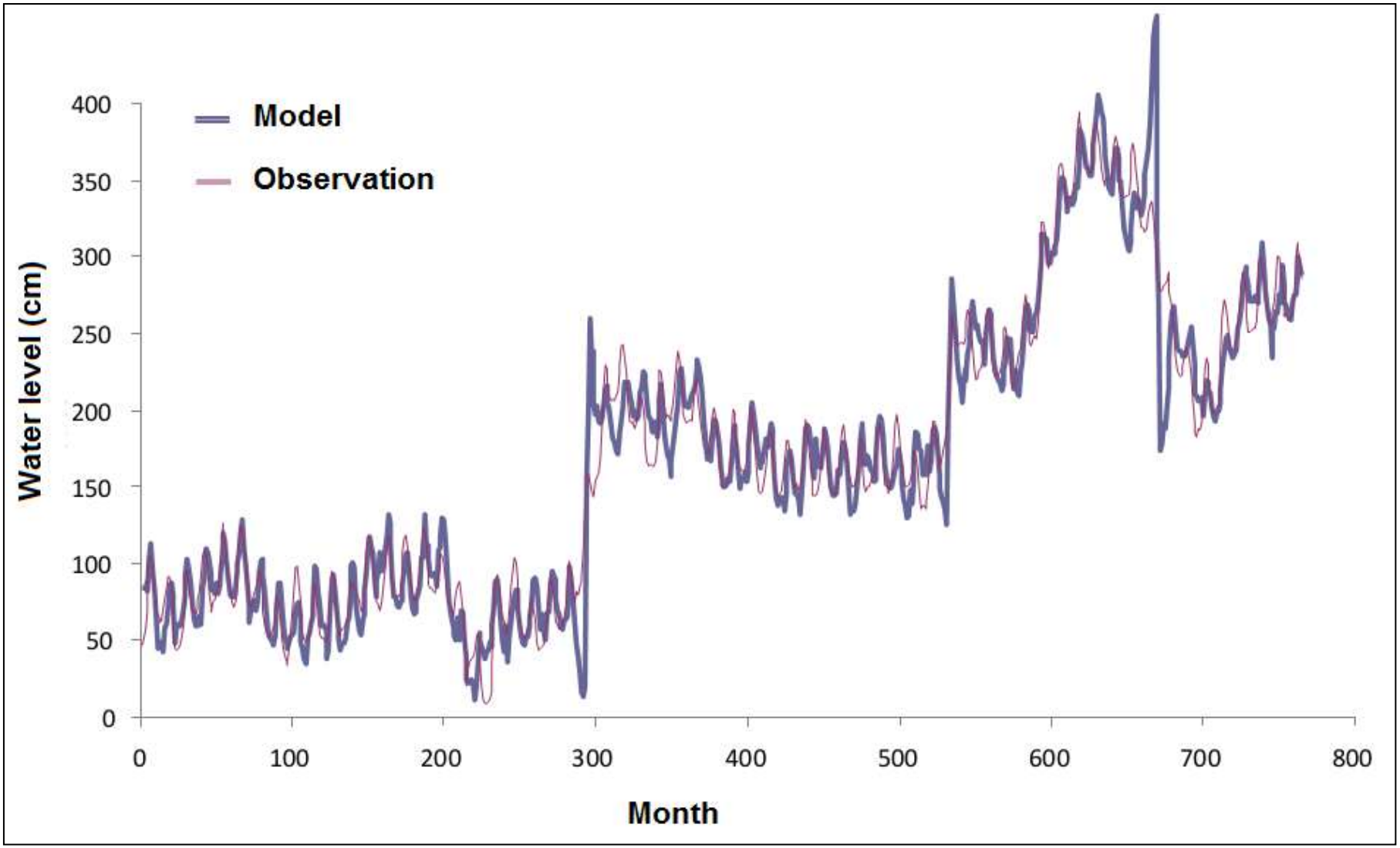
4-TREND LINE

Model	Variance, σ_ε^2	AIC
AR(1)	0.99	-9.446
AR(2)	0.60	-395.970
ARMA(1,1)	0.90	-53.070

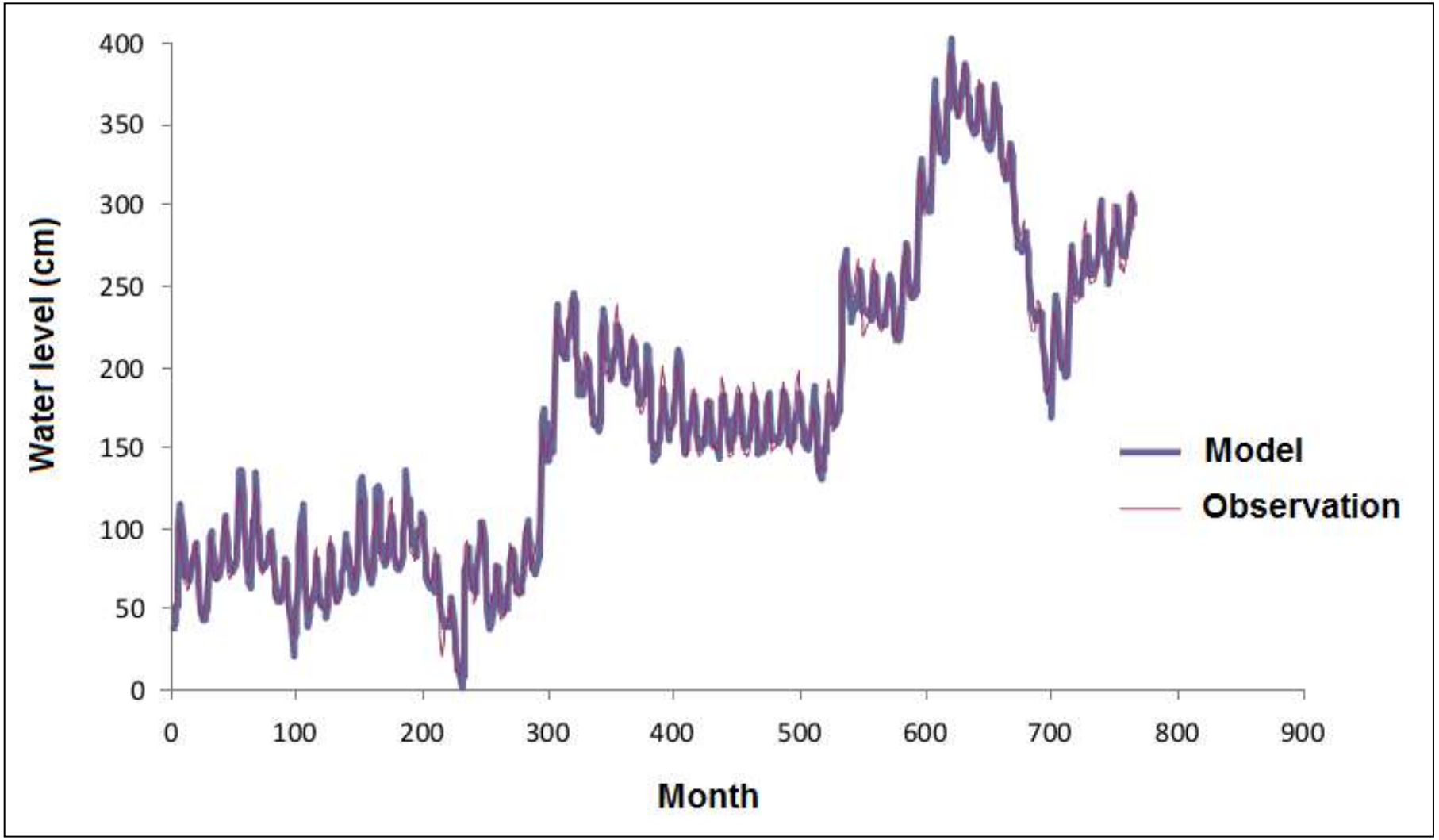


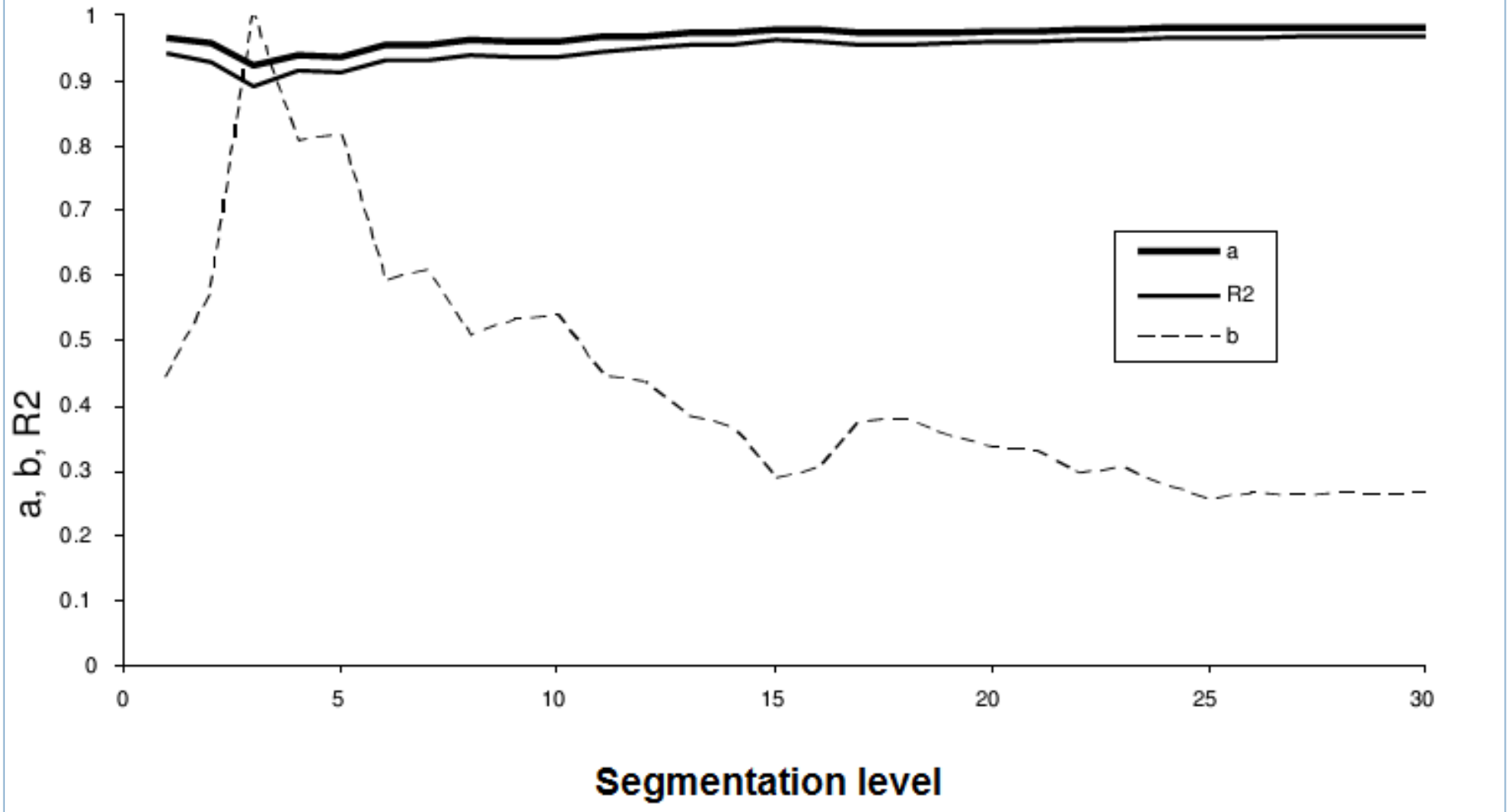
ϕ_1	-0.27
ϕ_2	-0.68
σ_ε^2	0.86

4-TREND LINE


Model
Observation
Water level (cm)
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600
700
800
Month

28-TREND LINE




a, b, R2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
a
R2
b
Segmentation level

SYNTHETIC SERIES

Return period (year)	Probability	Observed lake level (cm)	Synthetic lake level (cm)	
			One trend	*Four trends*
2	0.50	190.6	189.9	190.5
5	0.20	275.4	275.7	271.4
10	0.10	323.2	326.7	319.8
20	0.05	378.2	372.6	375.8
25	0.04	387.2	378.6	389.5
50	0.02	393.9	391.8	400.3
100	0.01		394.4	402.0
500	0.002		395.5	403.3
1000	0.001		395.9	404.5

RESULTS & CONCLUSIONS

- A stochastic model for monthly water levels for Lake Van
- One- and four-trend lines were adapted
- SEGMENTER was used to fit trend lines
- 1000-year length synthetic series were generated
- Maximum level for 50-year frequency is
  - One trend model 391.8 cm < observation value 393.9 cm.
  - Four trends model 400.3 cm > observation value 393.9 cm.
- Four trend model is more appropriate for planners and practitioners who want to be on the safe side.

THANK YOU…