Kuwait University
Civil Engineering Department
Water Resources Group

Crossing the Threshold of a Higher Order Urban Groundwater Level Forecast

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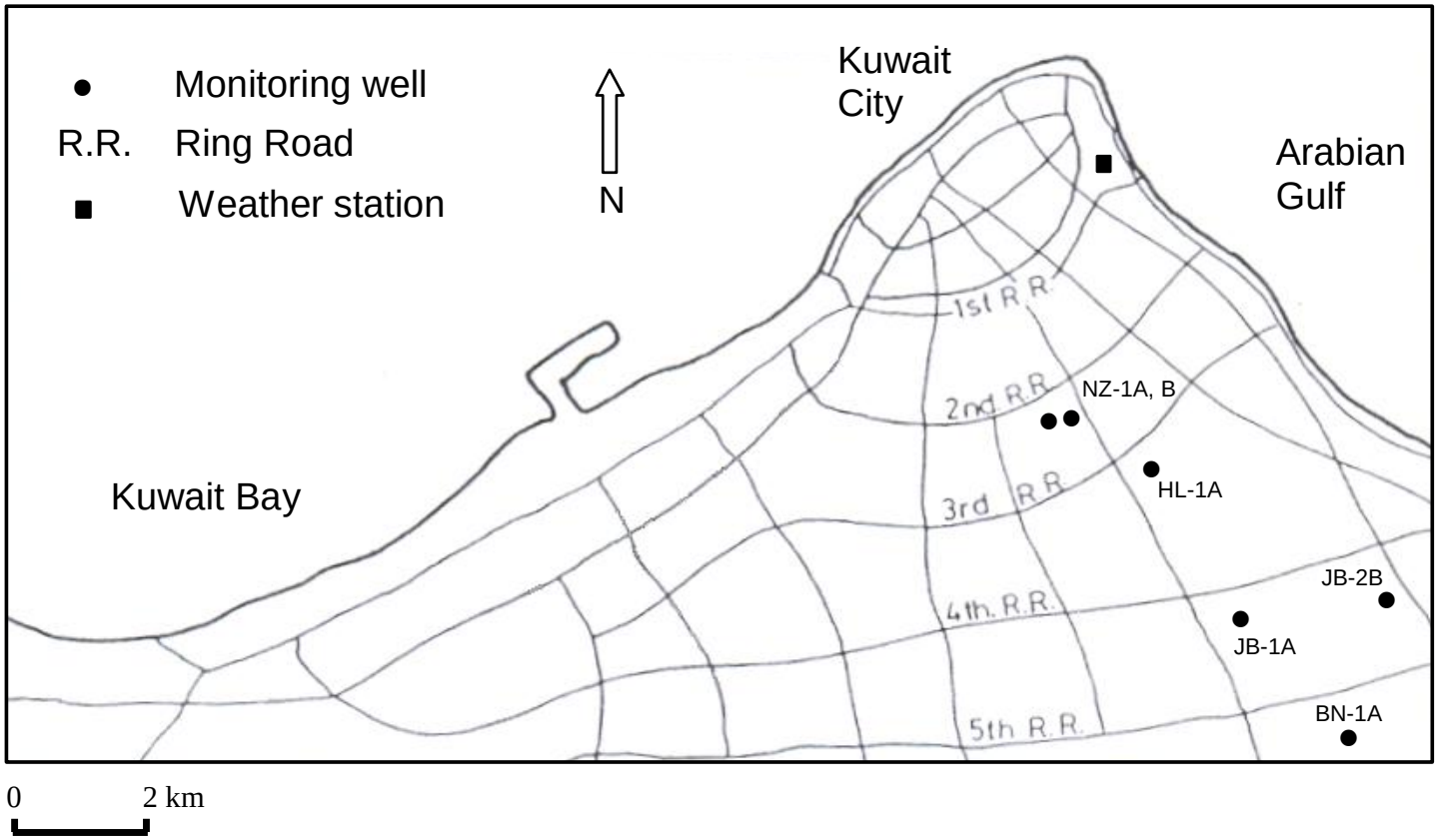
Introduction

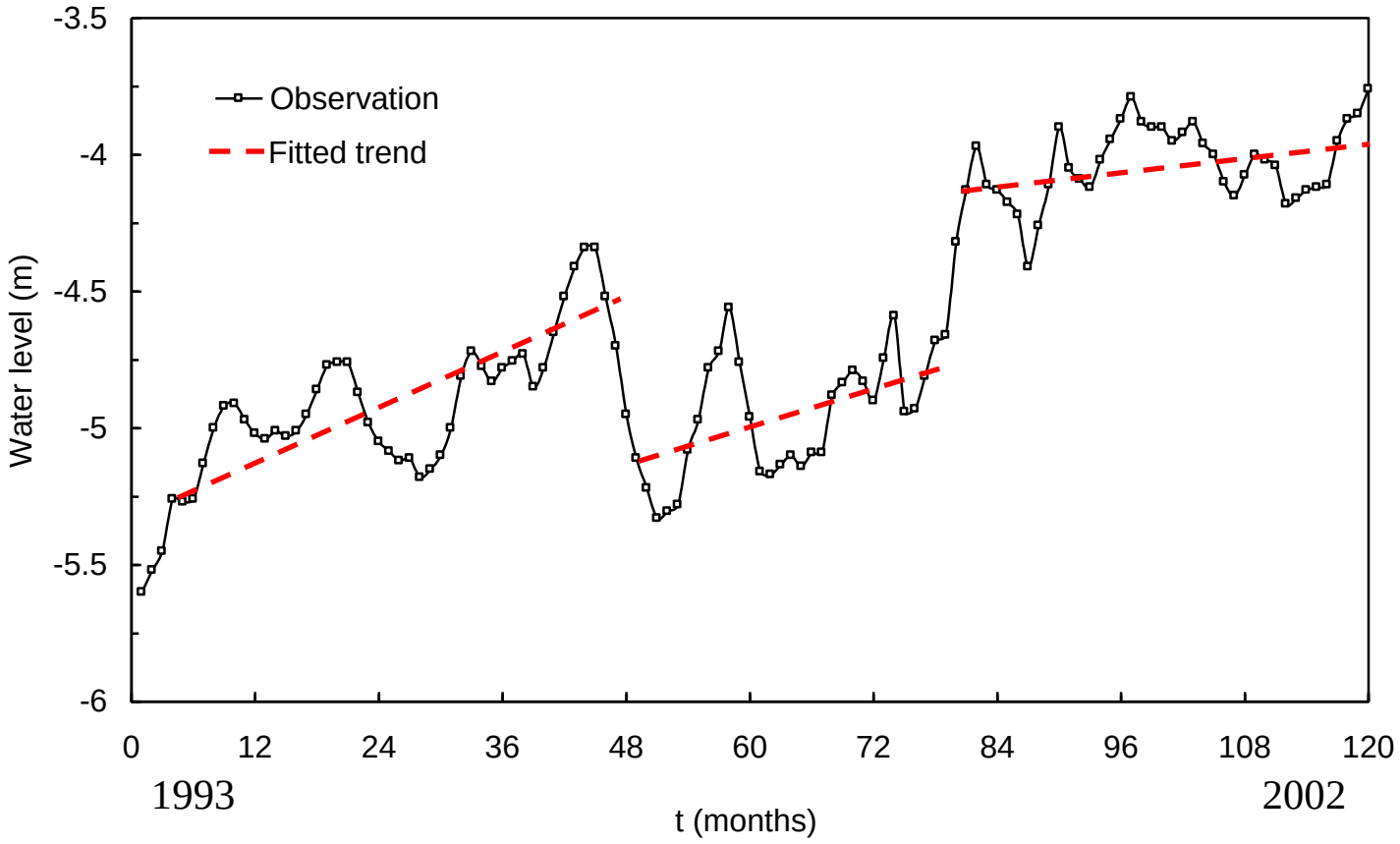
- Groundwater level increase constitutes a common problem in residential areas.
- It is believed that the source for this water is human-induced recharge activities.
- Evaluating directly the source of groundwater recharge might not be practically possible.
- Climatological parameters may be used to find in an indirect manner any causative relationship.

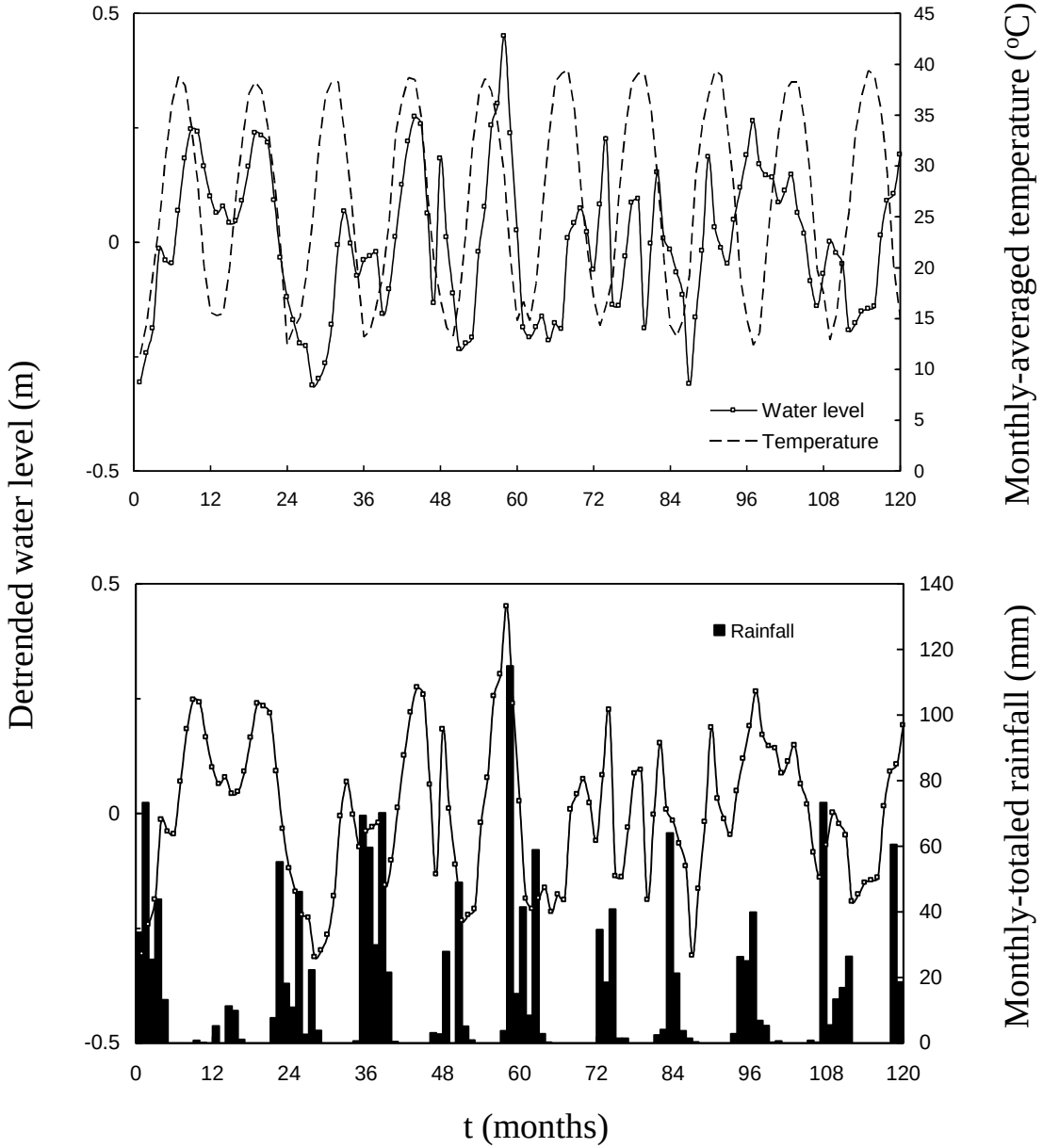
Objectives

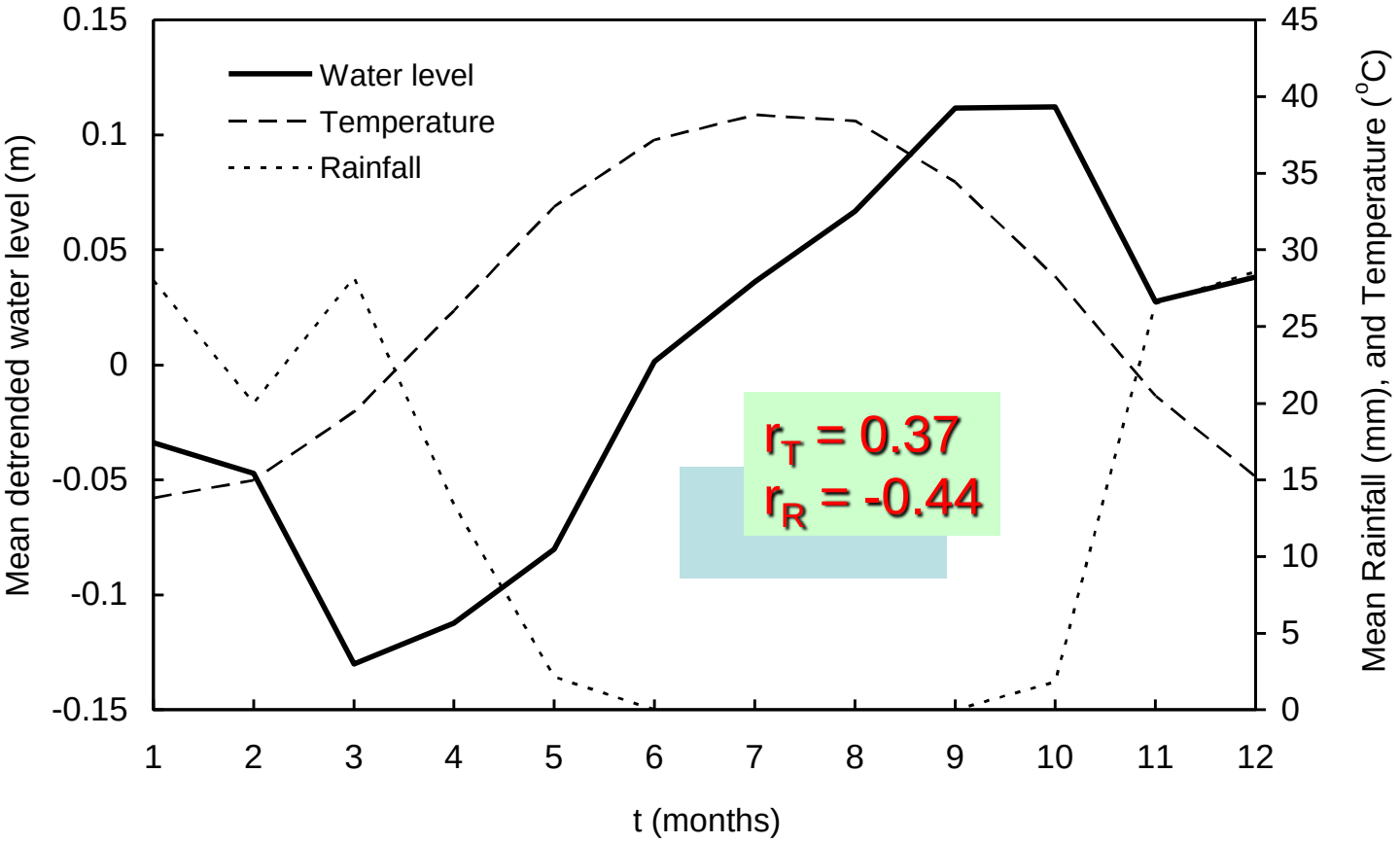
- To examine the correlation of groundwater level data with both temperature and rainfall data.
- To examine the cyclic structure of the three data sets in the frequency domain using the periodogram technique.
- To provide an attempt for modeling and forecasting groundwater level variation in residential areas.


Monitoring well
R.R. Ring Road
Weather station
N
Kuwait City
Arabian Gulf
Kuwait Bay
1st R.R.
2nd R.R.
3rd R.R.
4th. R.R.
5th R.R.
NZ-1A, B
HL-1A
JB-2B
JB-1A
BN-1A
0
2 km

HL-1A


Observation
Fitted trend
Water level (m)
-3.5
-4
-4.5
-5
-5.5
-6
0
12
24
36
48
60
72
84
96
108
120
1993
2002
t (months)


Detrended water level (m)
Monthly-averaged temperature (ºC)
Water level
Temperature
Monthly-totaled rainfall (mm)
Rainfall
t (months)
0.5
0
-0.5
45
40
35
30
25
20
15
10
5
140
120
100
80
60
0
12
24
36
48
60
72
84
96
108
120



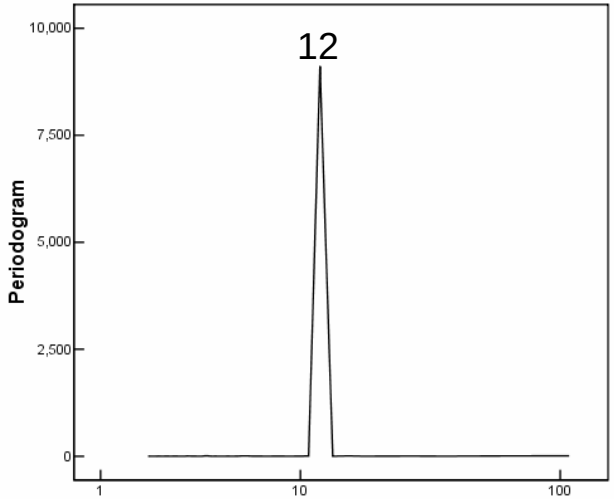
$$\bar{j} = \frac{1}{N}\sum_{\nu=1}^{N} j_{\nu,\tau} \qquad \tau = 1,\ldots,12$$

j = seasonal time series

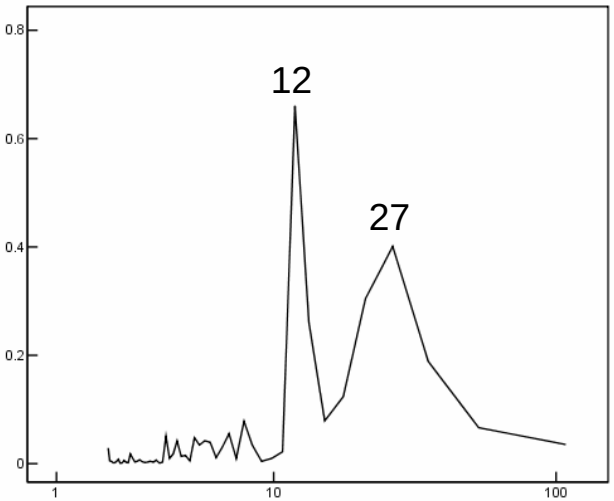
$\bar{j}$ = seasonal mean

N = total number of years

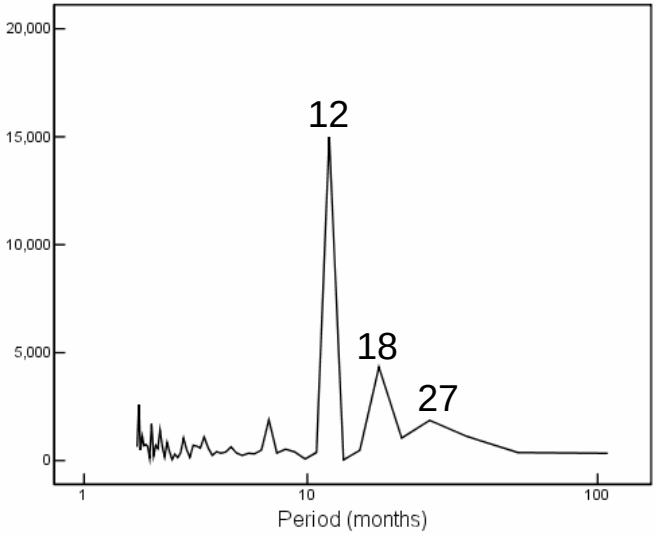
Monthly-averaged temperature



Detrended water level



Monthly-totaled rainfall



Data characteristics of monitoring wells

Well no.	Duration (year)	[a]Water Level (m)	r_T	r_R	Periodicity (months)
BN-1A	1992-2001	8.42-12.23	0.35	-0.29	12, 20, 30
JB-1A	1993-2002	4.52-6.08	0.26	-0.37	12, 17
JB-2B	1993-2002	1.92-2.56	0.43	-0.58	12
HL-1A	1993-2002	3.76-5.60	0.37	-0.44	12, 27
NZ-1A	1992-2000	2.68-4.07	0.36	-0.43	12, 18
NZ-1B	1993-2000	2.68-4.07	0.34	-0.43	12, 19

[a]Below ground surface

Trend

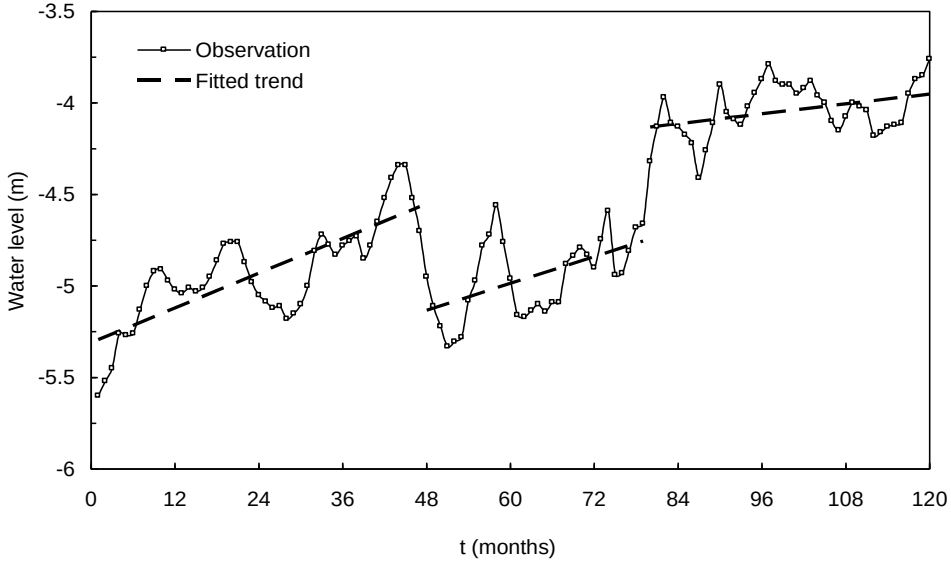
Seasonality

Error

$$h(t) = y(t) + s(t) + \varepsilon(t)$$

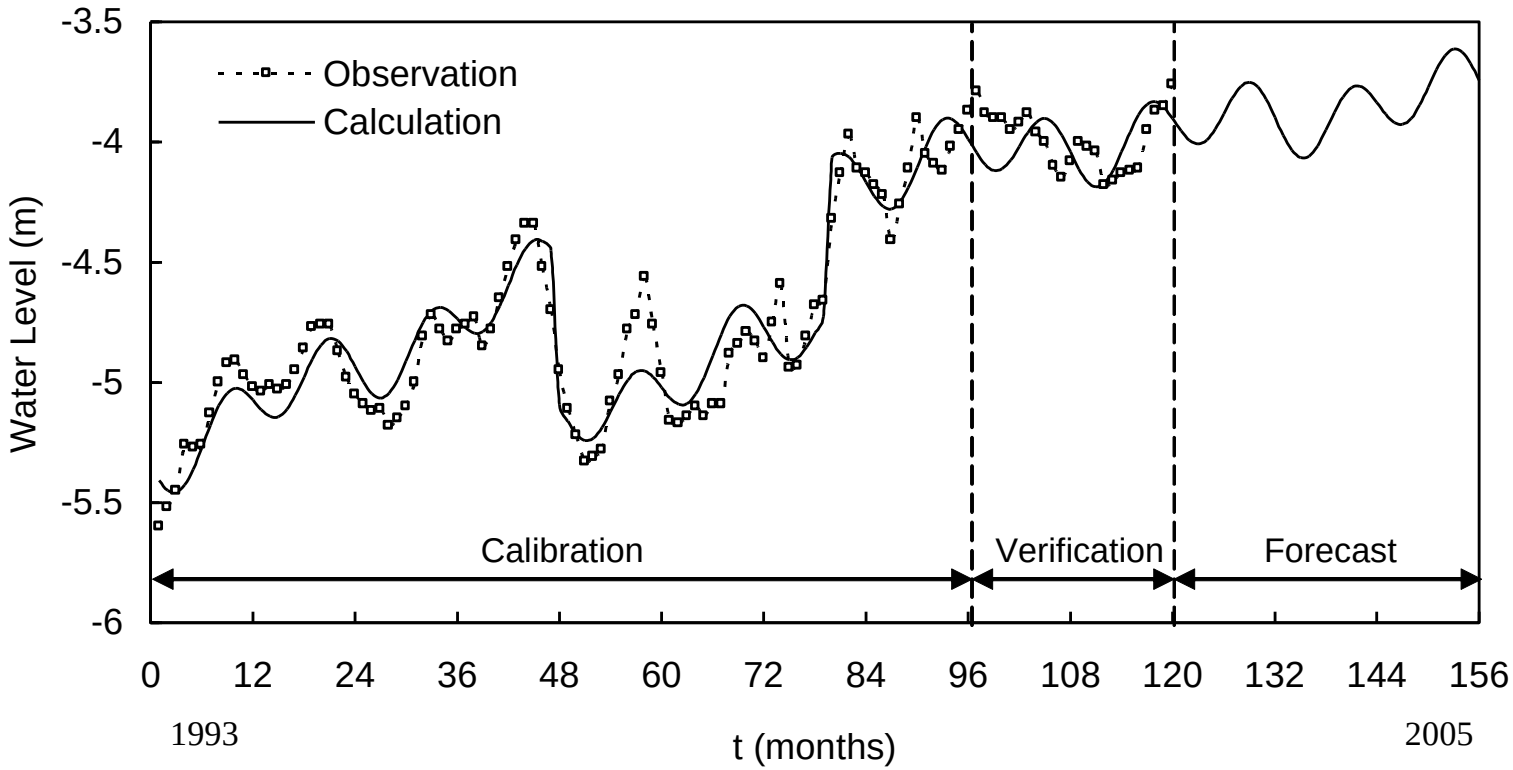
Water level

HL-1A



$$y(t) = \begin{cases} 0.0158t - 5.3091, & \text{if } t < 48 \\ 0.0122t - 5.7302, & \text{if } 48 \le t < 80 \\ 0.0045t - 4.4914, & \text{if } t \ge 80 \end{cases}$$

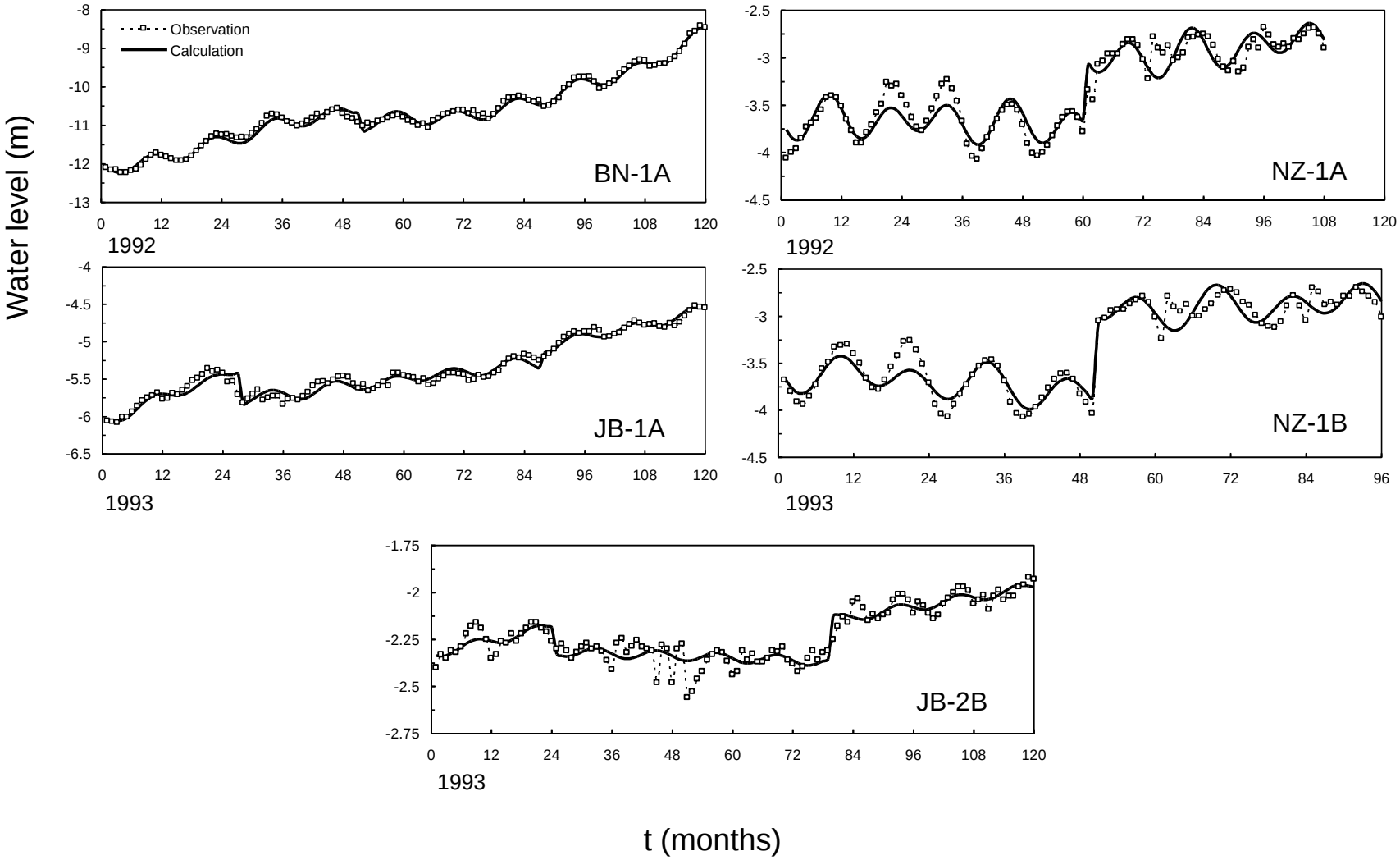
$$s(t) = 0.11067\cos\left(\frac{2\pi}{12}t + 1.526\right) - 0.086376\cos\left(\frac{2\pi}{27}t - 0.64181\right)$$



MAE = 0.105 m

MAE = 0.097 m

$$\mathrm{MAE} = \frac{1}{N}\sum_{i=1}^{N}\left|h_{i\ observed} - h_{i\ calculated}\right|$$


Observation
Calculation
BN-1A
NZ-1A
JB-1A
NZ-1B
JB-2B
1992
1993
Water level (m)
t (months)

Conclusions

- The examined data of groundwater level is correlated with temperature and rainfall.
- The periodogram technique can provide means for modeling and forecasting the variation pattern of groundwater level data.