Underground water observation in "Wari-ishi hot spring", Gifu Prefecture

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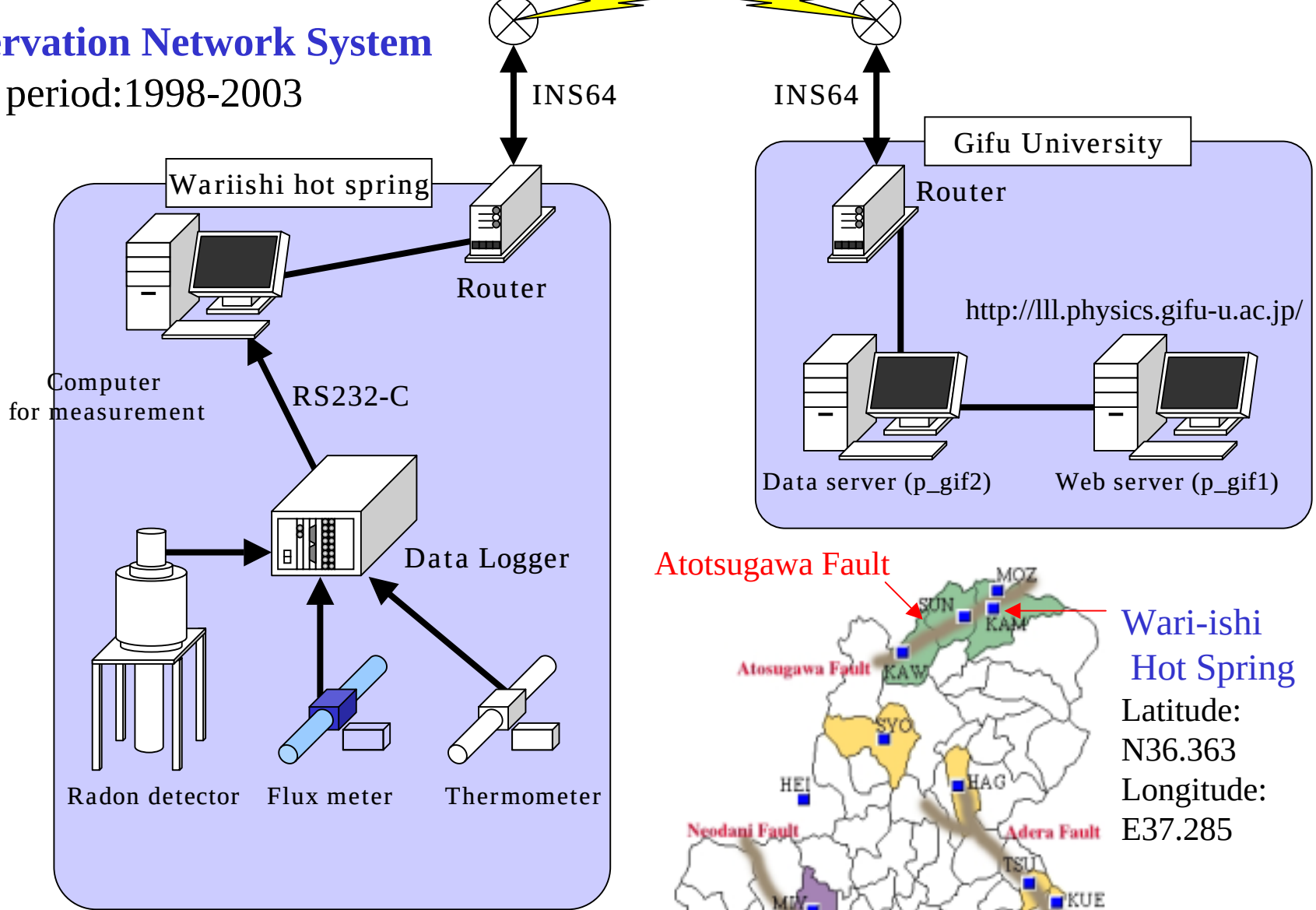
Observation Network System

2nd period:1998-2003



Wari-ishi Hot Spring

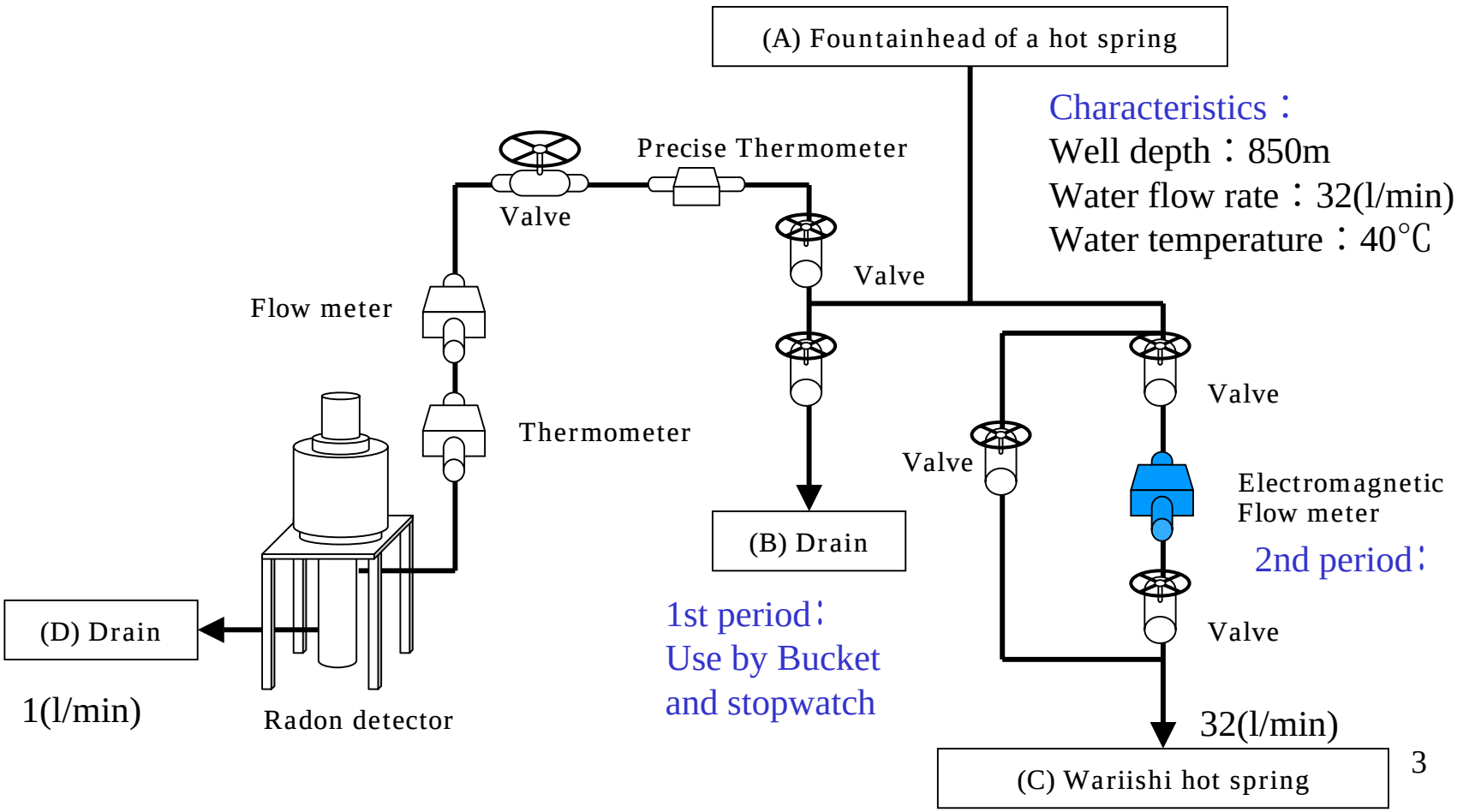
Latitude: N36.363

Longitude: E37.285

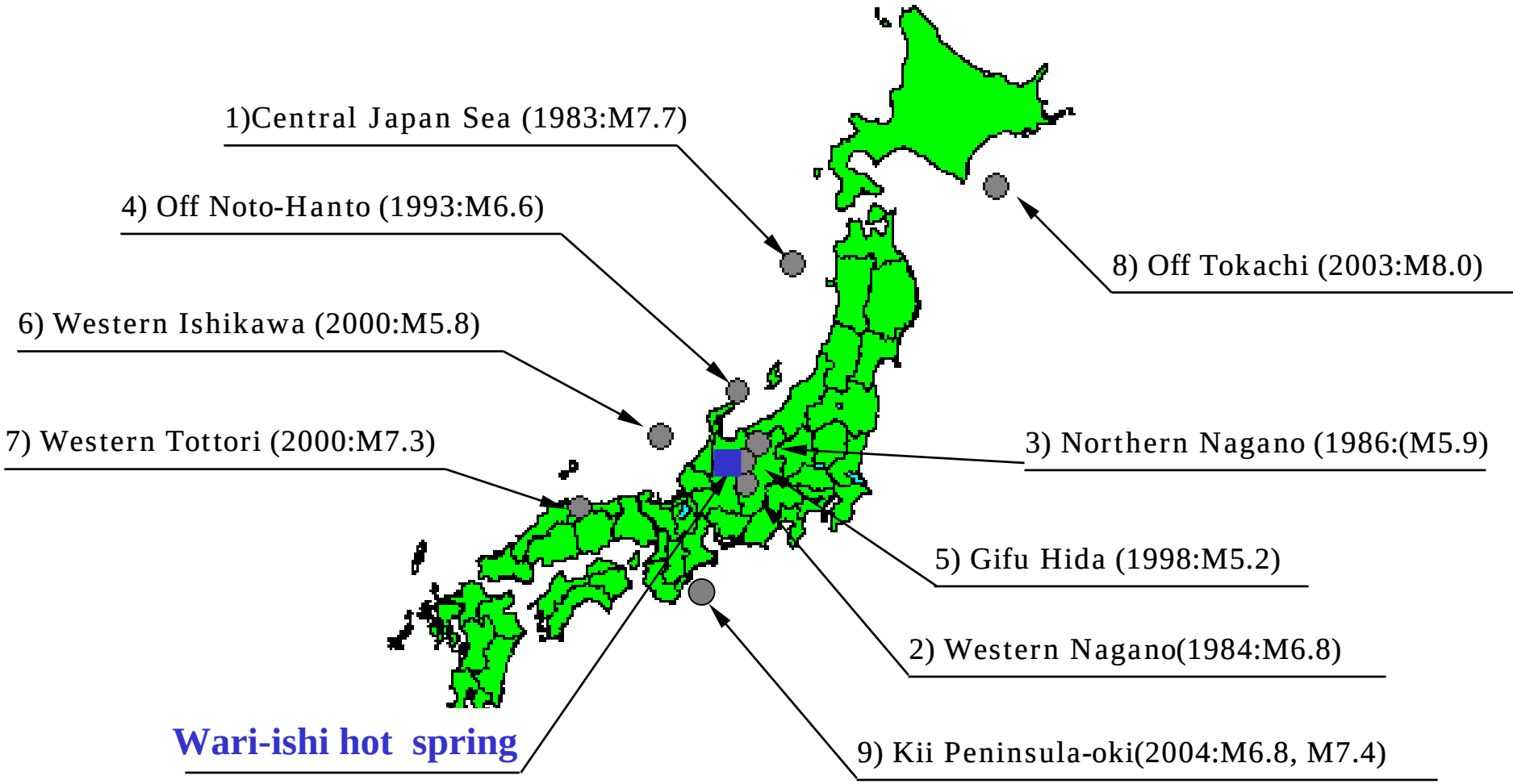
Underground Water observation System

1st period:1977～1998：bucket and stopwatch（every Monday）

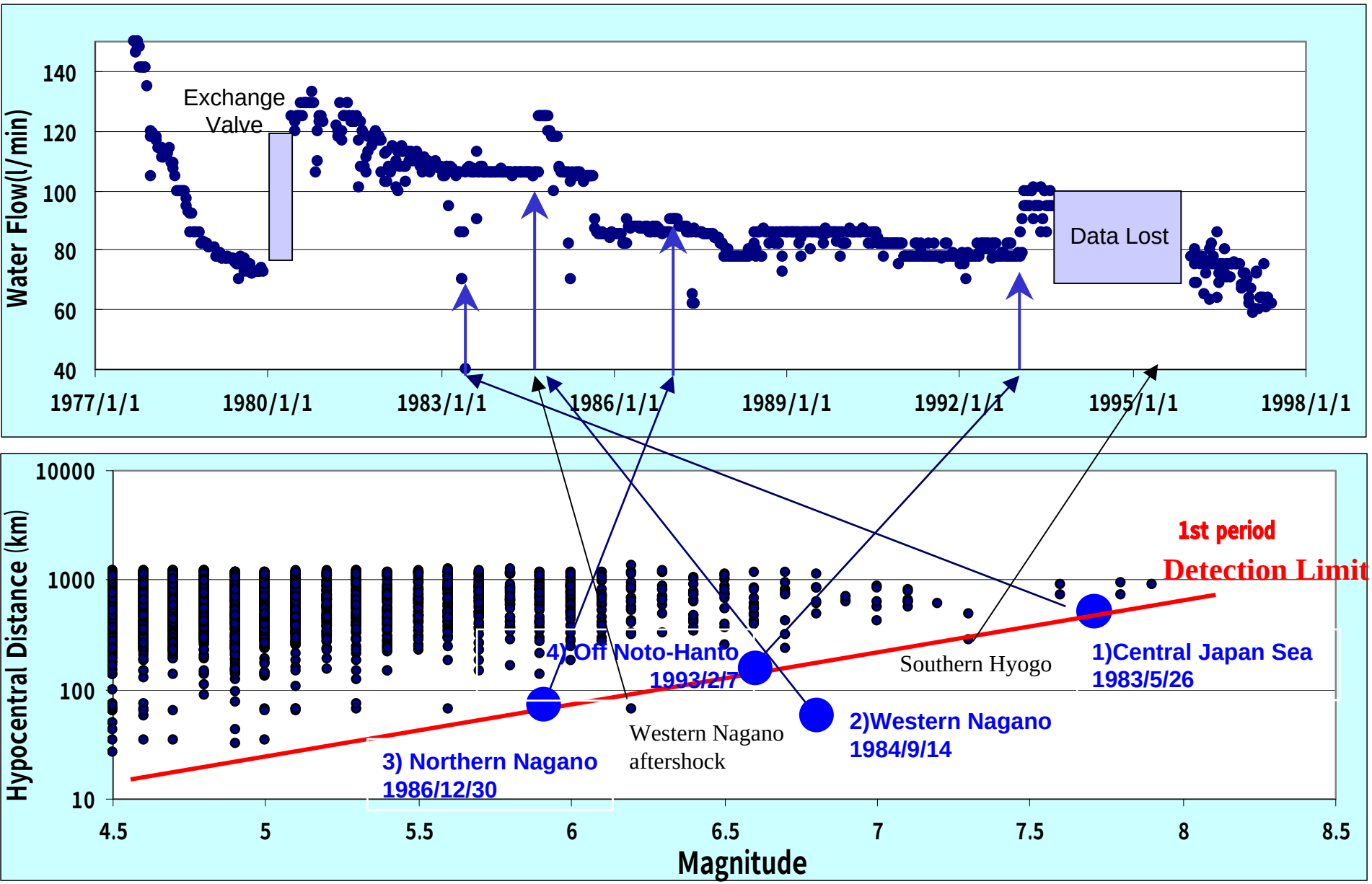
2nd period:1998～2003：Electromagnetic Flow Meter
（continuous measurement in 10 min interval）



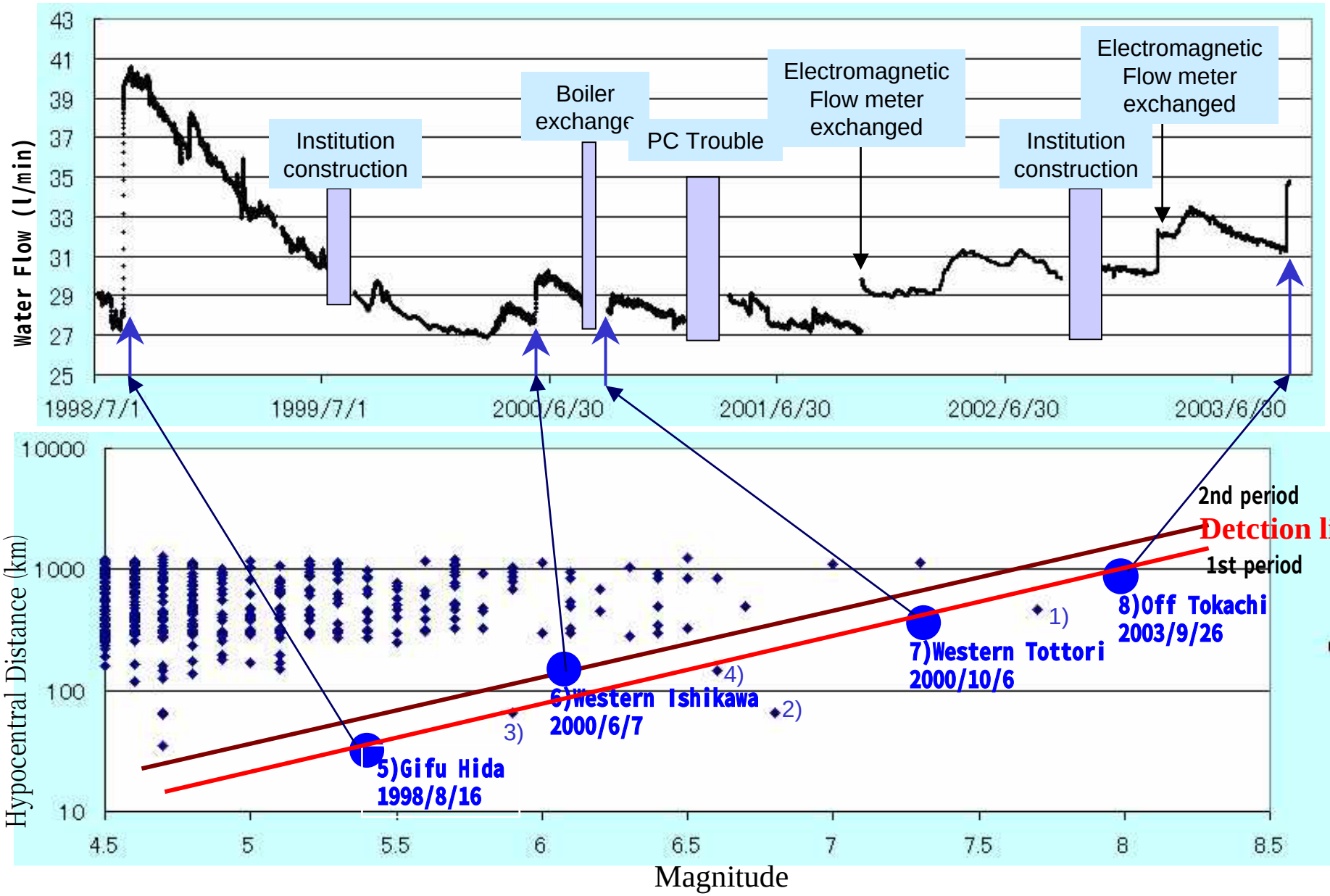
Change of Water Flow Rate with Earthquakes(1977-2004)



Threshold of Detection in Change of the Flow Rate (1st observation period:1977-1997)

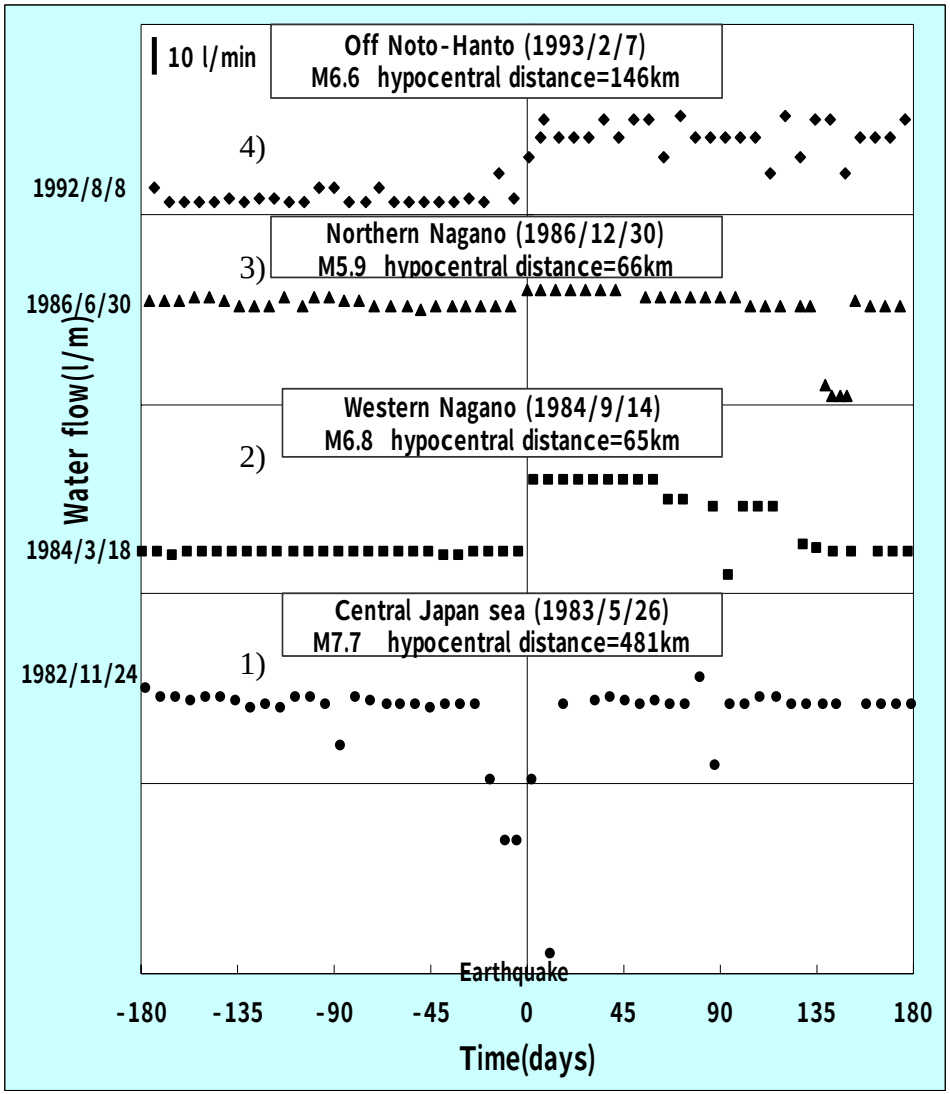


Threshold of Detection in change of Flow Rate (2nd observation period:1998-2003)



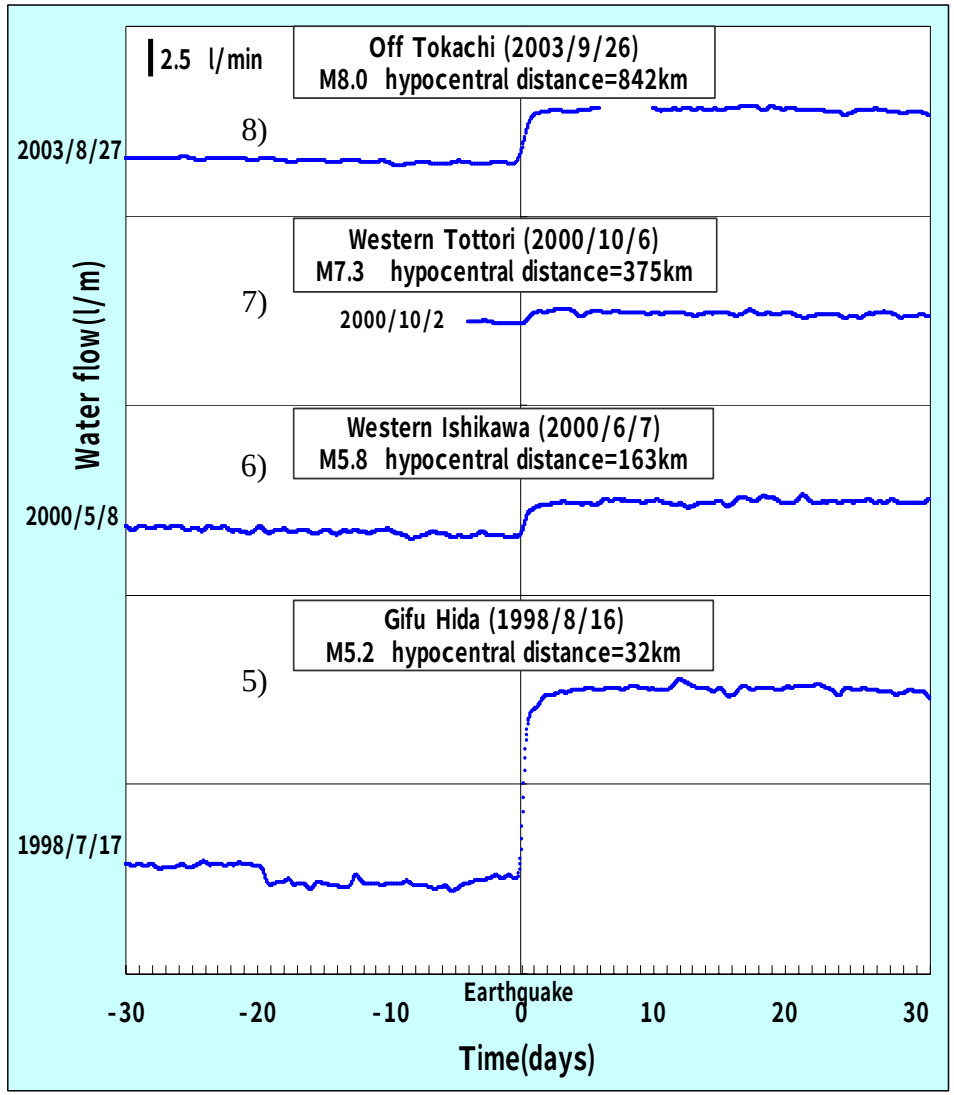
Change of Flow Rate Associated with Earthquakes

4 EQ(1st period:1977-1997)



Data in a year

4 EQ(2nd period:1998-2003)



Data in 2 months

Tidal Response(2nd period:1998-2003)

Flow Rate | Atmospheric Pressure

↓ ↓

Tidal Response (BAYTAP-G program)

↓

Flow Rate
- Trend component
- Atmospheric comp.
- **Irregular component** → Irregular component (Noise) Solved Gas

1) Amplitudes of water flow in earth and oceanic tide

M2：12.42h 0.159(l/min)

O1：25.82h 0.100(l/min)

2) Tidal Strain calculated by GOTIC2

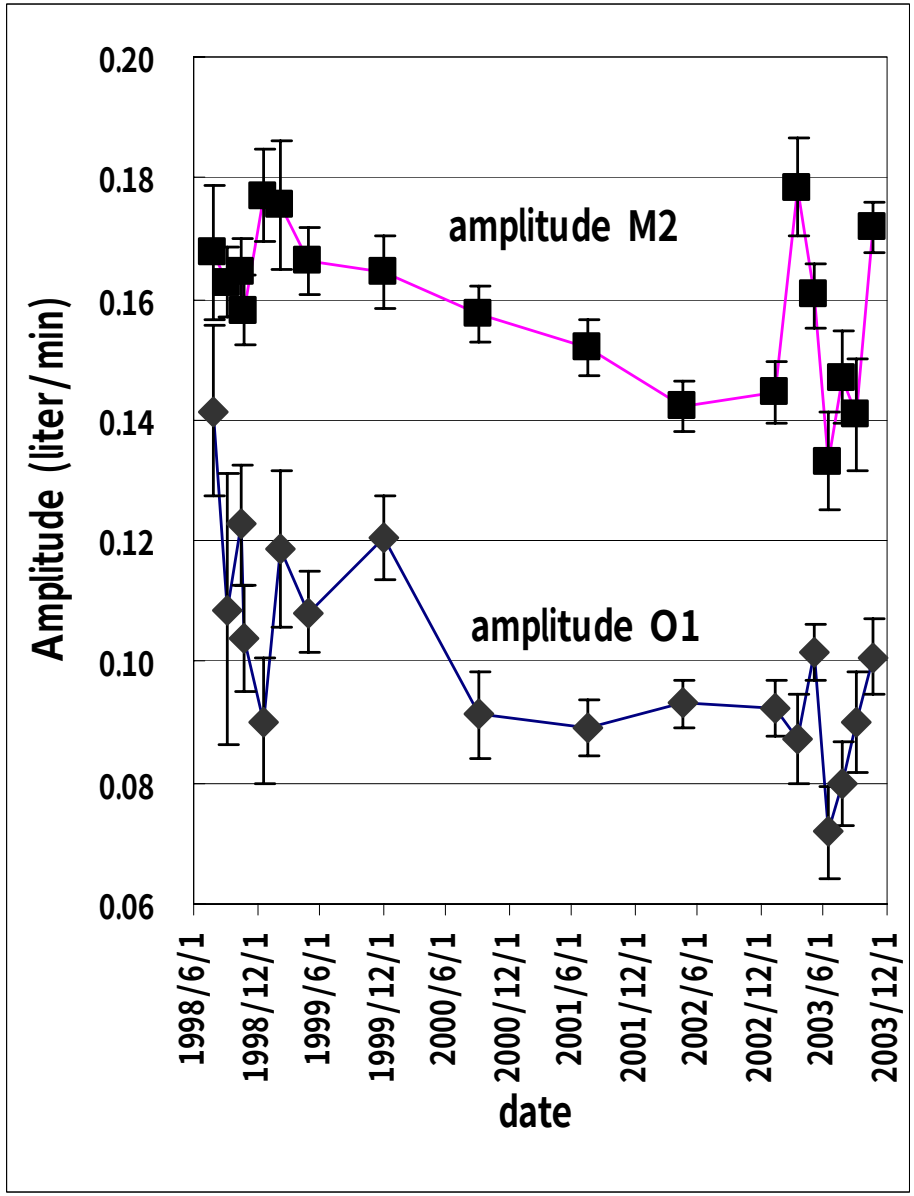
M2:0.997(×10^{-8} cubic strain)

O1:0.671(×10^{-8} cubic strain)

3) Sensitivity of water flow in Tidal Strain

M2:0.16(l/min)/(×10^{-8} cubic strain)

O1:0.15(l/min)/(×10^{-8} cubic strain)



Water Flow Change and Volumetric Strain by Fault Model

No.	Earthquake	Water Flow before earthquake (liter/min)	Change of Water Flow after earthquake (liter/min)	Volumetric Strain by Tidal Response (10-8 cubic strain)	Volumetric Strain by Earthquake fault model (10-8 cubic strain)
1)	Central Japan Sea	106	-36.0	-60.7	-0.391
2)	Western Nagano	106	19.0	32.0	0.775
3)	Northern Nagano	86	4.0	8.3	-0.511
4)	Off Noto-Hanto	78	11.0	25.2	0.120
5)	Gifu Hida	27.5	11.7	73.1	0.467
6)	Western Ishikawa	27.5	1.8	11.3	0.064
7)	Western Tottori	28	0.7	4.4	0.038
8)	Off Tokachi	31.5	3.0	18.8	-0.219

5)-8)EQ：sensitivity:0.16(l/min)/(×10^{-8} cubic strain)

1)-4)EQ：assumption of sensitivity in proportion to flow rate

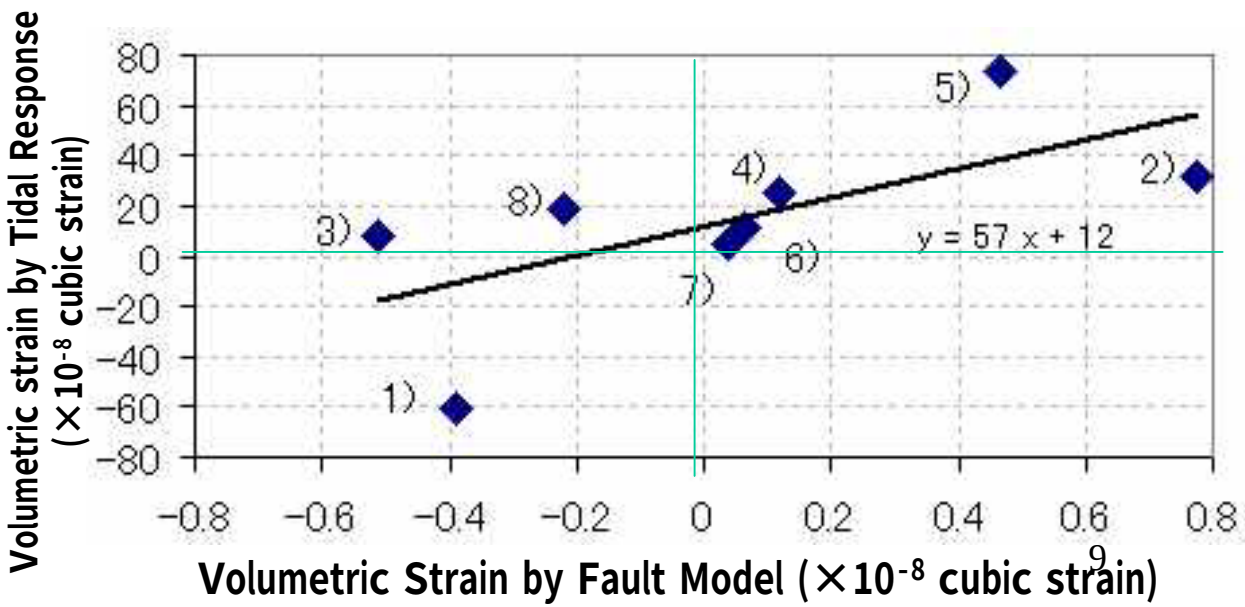
+:Dilatation

-:Contraction

Volumetric Strain was calculated by EQ fault model using the MICAP-G program.

Expected Volumetric Strain was calculated by Tidal Response from change of water flow.

Change of flow rate associated with 8 EQ were 60 times larger than the values expected from EQ fault model.



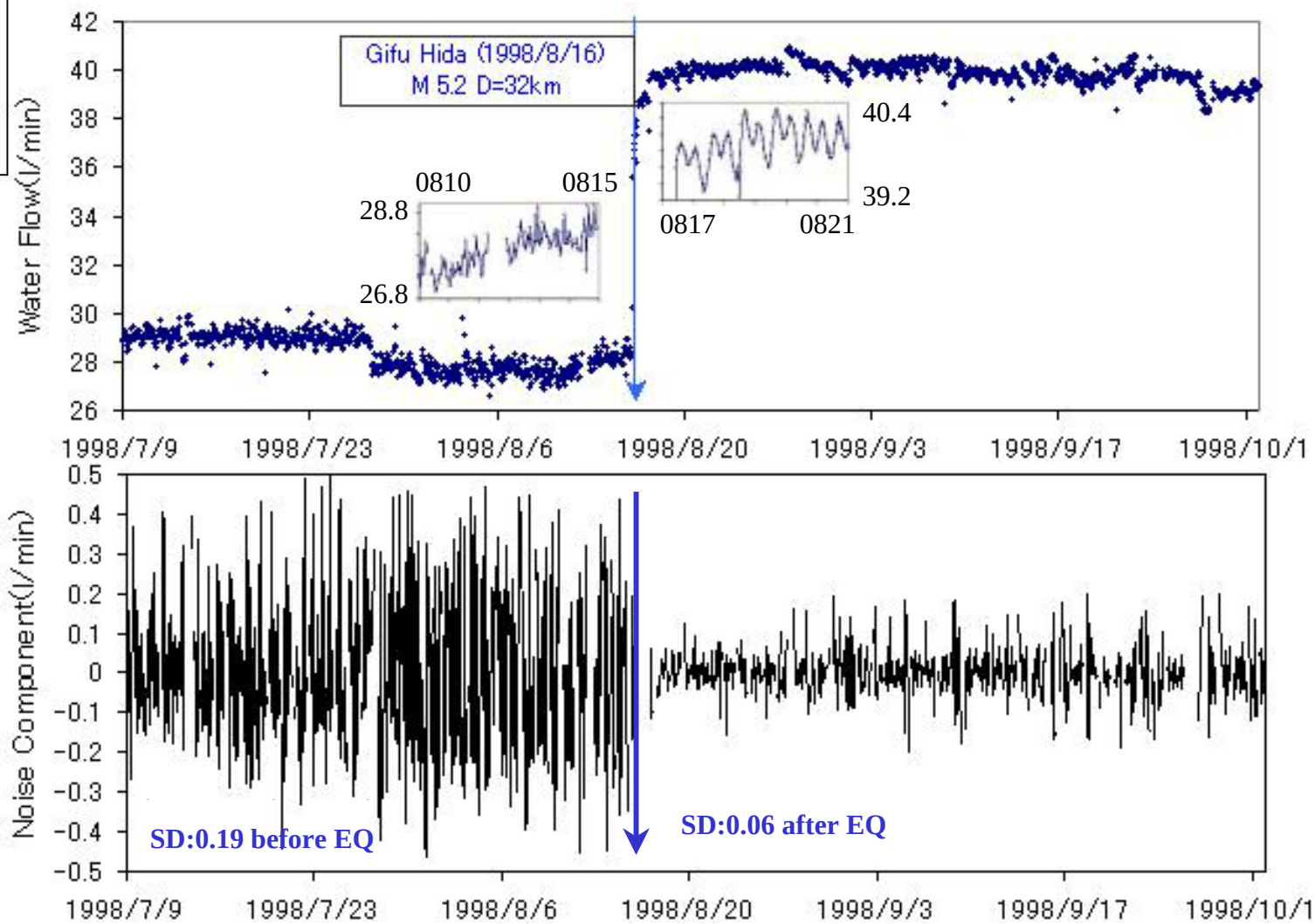
Noise component of water flow and dissolved Gas

Hida Gifu (1998/8/16:M5.2, D=32km)

•Tidal fluctuation after EQ clearly identified.

•Dissolved Gas effect on the data of electromagnetic flow meter.

•Fluctuation of Water flow data related with the amount of gas.



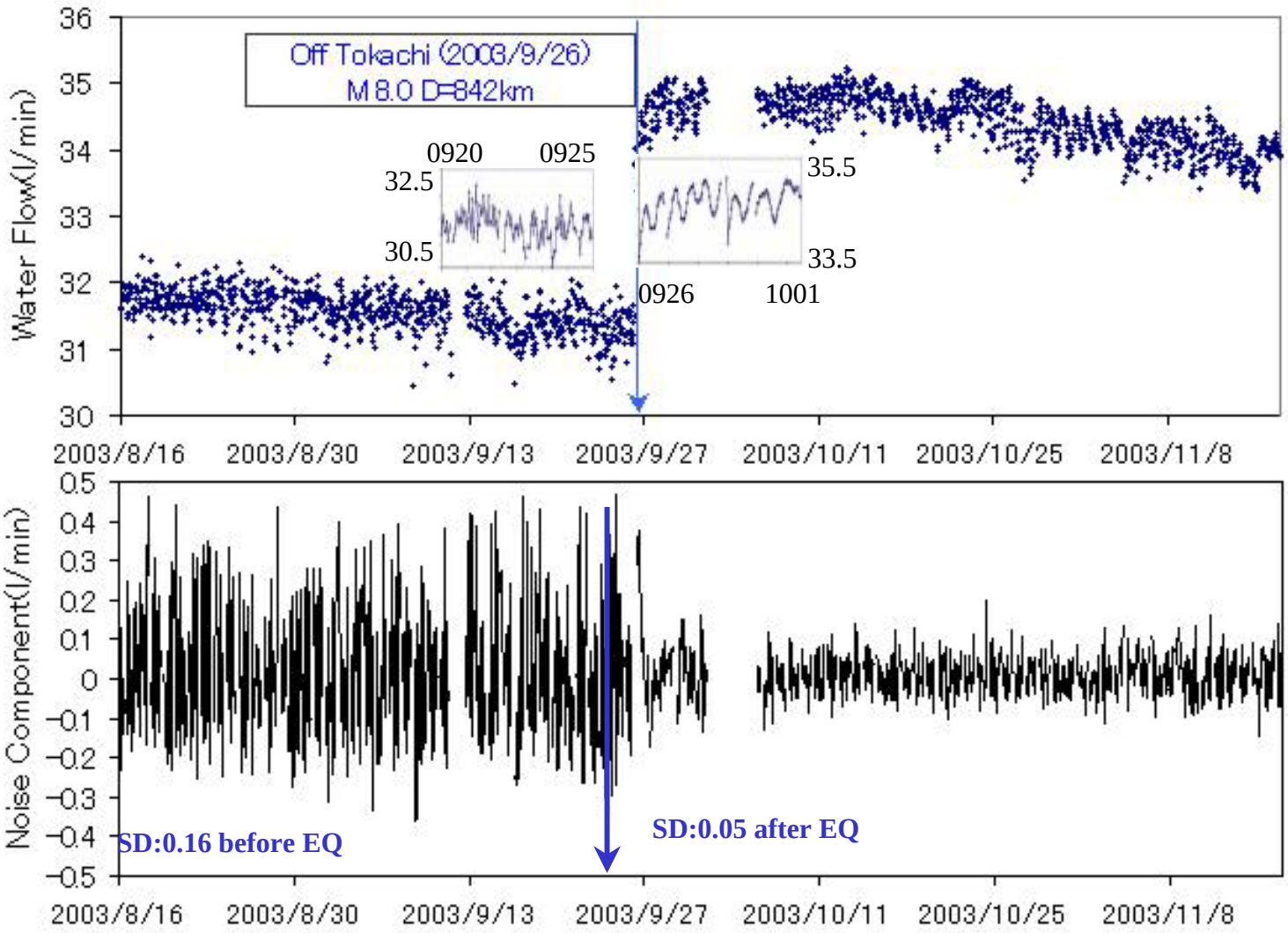
•Noise component was decreased with 1/3 after EQ occurrence.

Noise component of water flow and dissolved Gas

Off Tokachi (2003/9/26:M8.0, D=842km)

•Tidal fluctuation after EQ clearly identified.

•Because of the strain change by earthquake ,dis solved gas gushed out from the well.
•Unexpected change of water flow rate was observed.



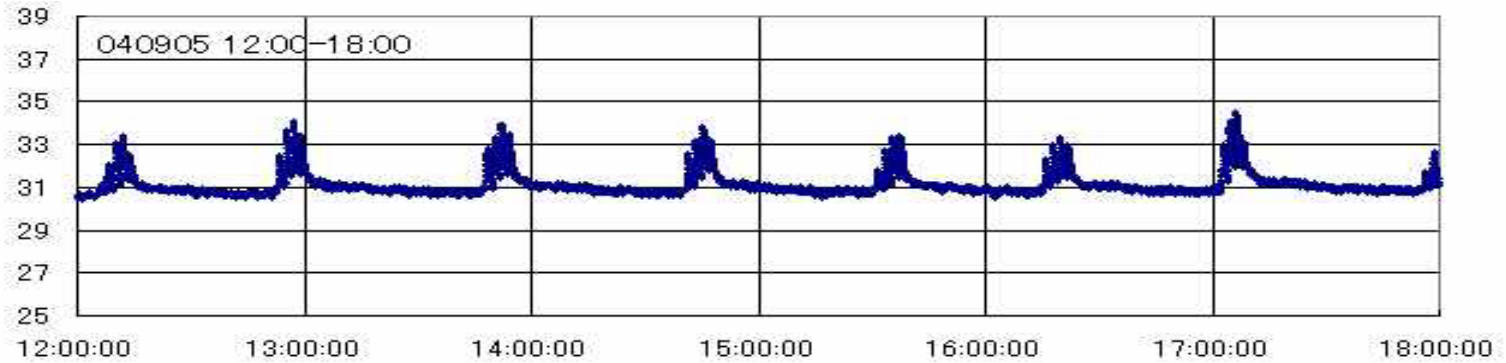
•**Noise component was decreased with 1/3 after EQ occurrence.**

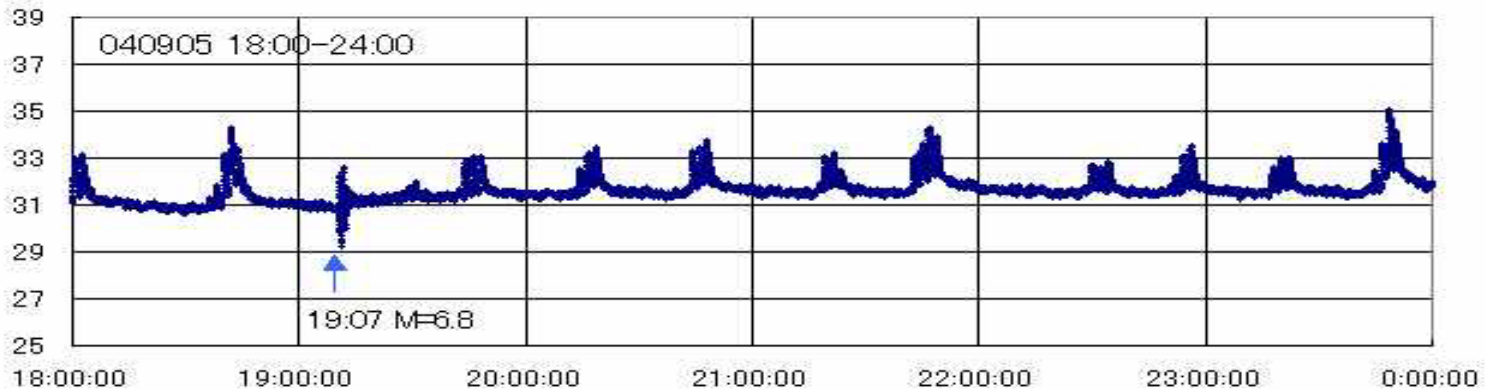
Change of spring water in Kii Peninsula-Oki Earthquakes 5-September

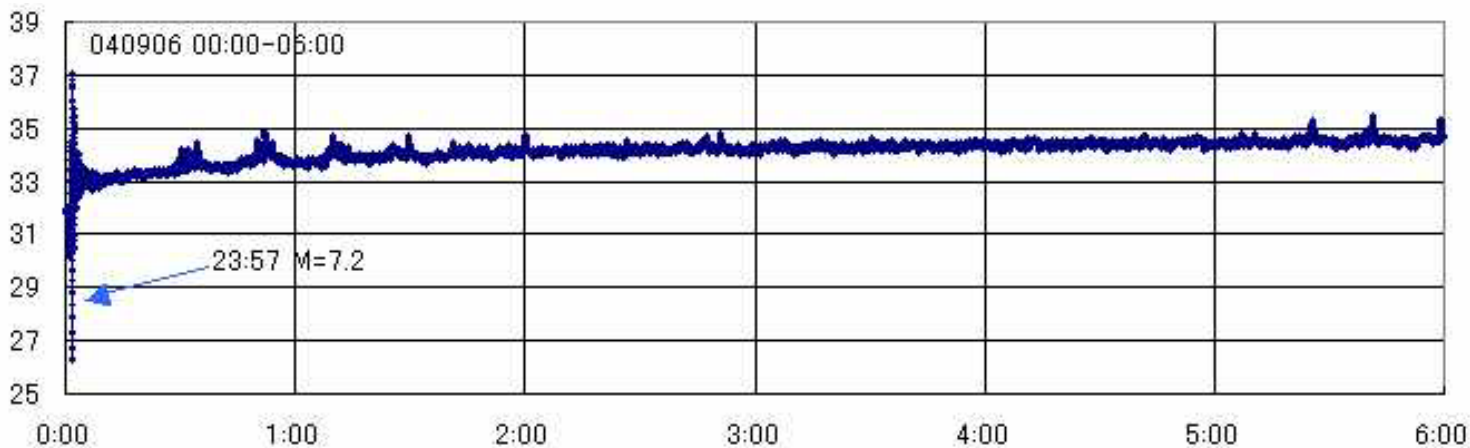
New data logger installed to take the precise water flow data with the 1Hz frequent, on 28-July.

Kii-Peninsula-oki earthquake
05-Sep,2004
19:07 M=6.8 ,
23:57 M=7.2
in “Wari-ish hot spring”

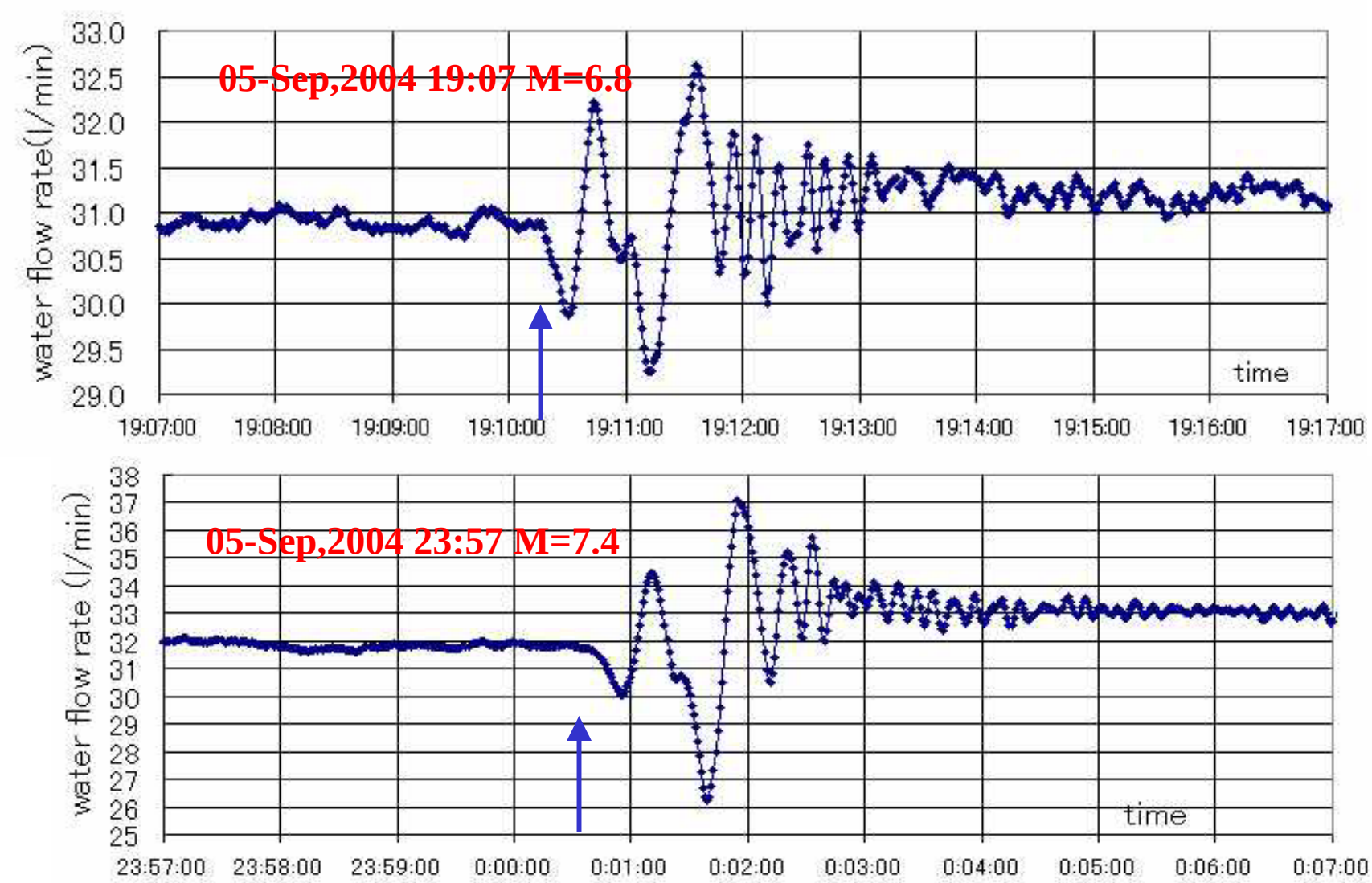
We can see the periodically water increase before EQ, water lift were disappeared after EQ.







Detailed 1Hz Data in Kii Peninsula earthquake



Water flow rate increase to be 0.5and 1.0(l/min) in two earthquakes, respectively. Wave amplitude to be ±1.5 and ±5(l/min). Initial change was started with the delay time of about 210sec, and we can see the direction of the strain to be Contraction from 1Hz water flow data.

Summary

1)Observation of water flow rate in the last 27 years

the first period:1977～1997：bucket and stopwatch

the second period:1998～2003：electromagnetic flow meter

2)Detection limit in the change of flow rate

Hypocenter Distance–Magnitude scatter plots

Co-seismic change of water flow rate associated with 8 EQ

3)Tidal Response (1998-2003)

Sensitivity for change of water flow rate in Tidal Strain

→0.16(l/min)/(10^{-8} volumetric strain)

Volumetric strain from water flow rate associated with 8 EQ were 60 times larger than the values calculated from EQ fault model.

4)Noise component of water flow rate and resolved Gas (Hida Gifu, Off Tokachi)

Noise component was decreased with 1/3 after EQ occurrence.

Because of the strain change by earthquake ,dissolved gas gushed out from well. Unexpected change of water flow rate was observed.