

# Earthquake pre-seismic and co-seismic changes of the hot spring water in Central Part of Japan

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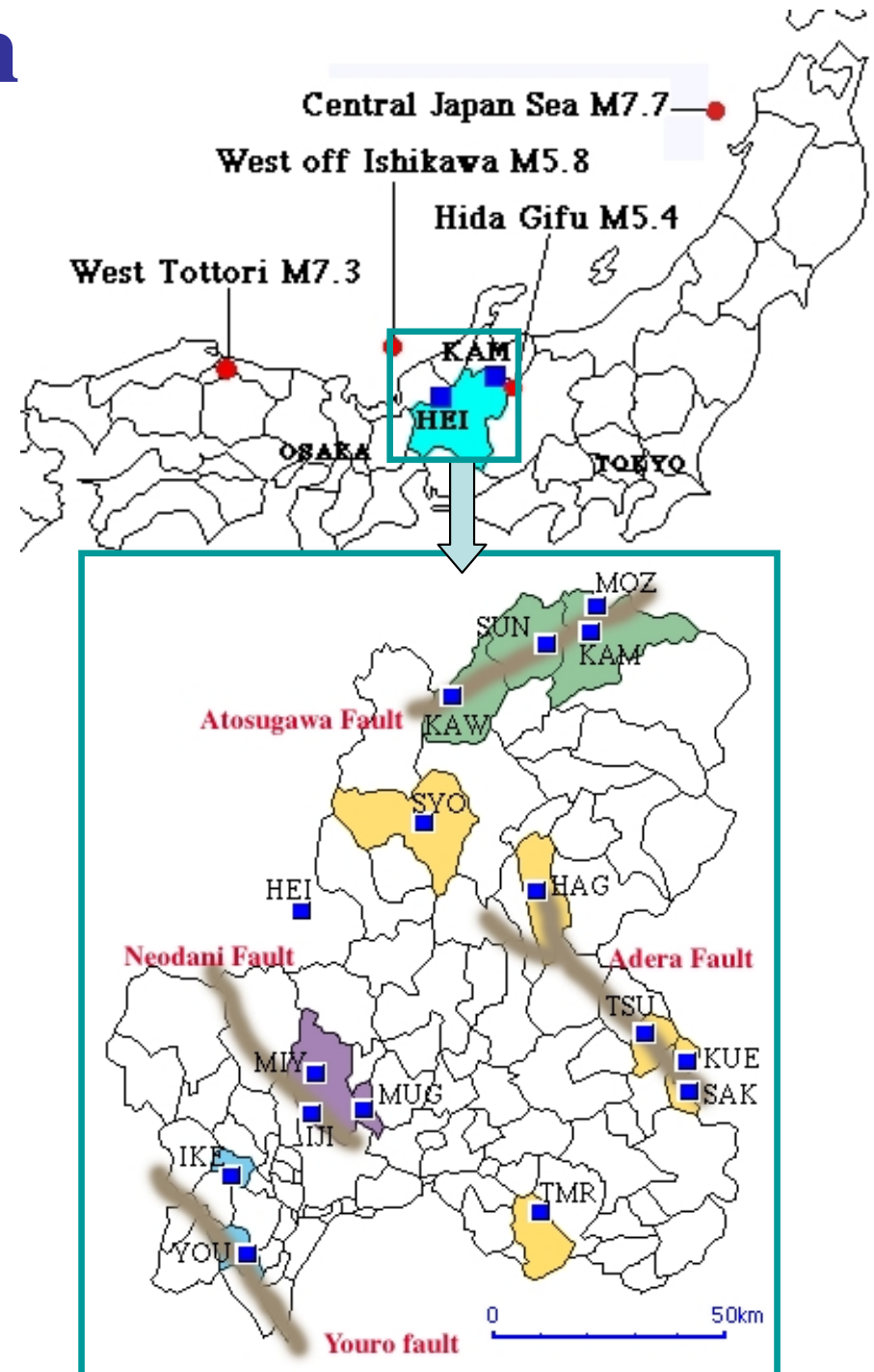
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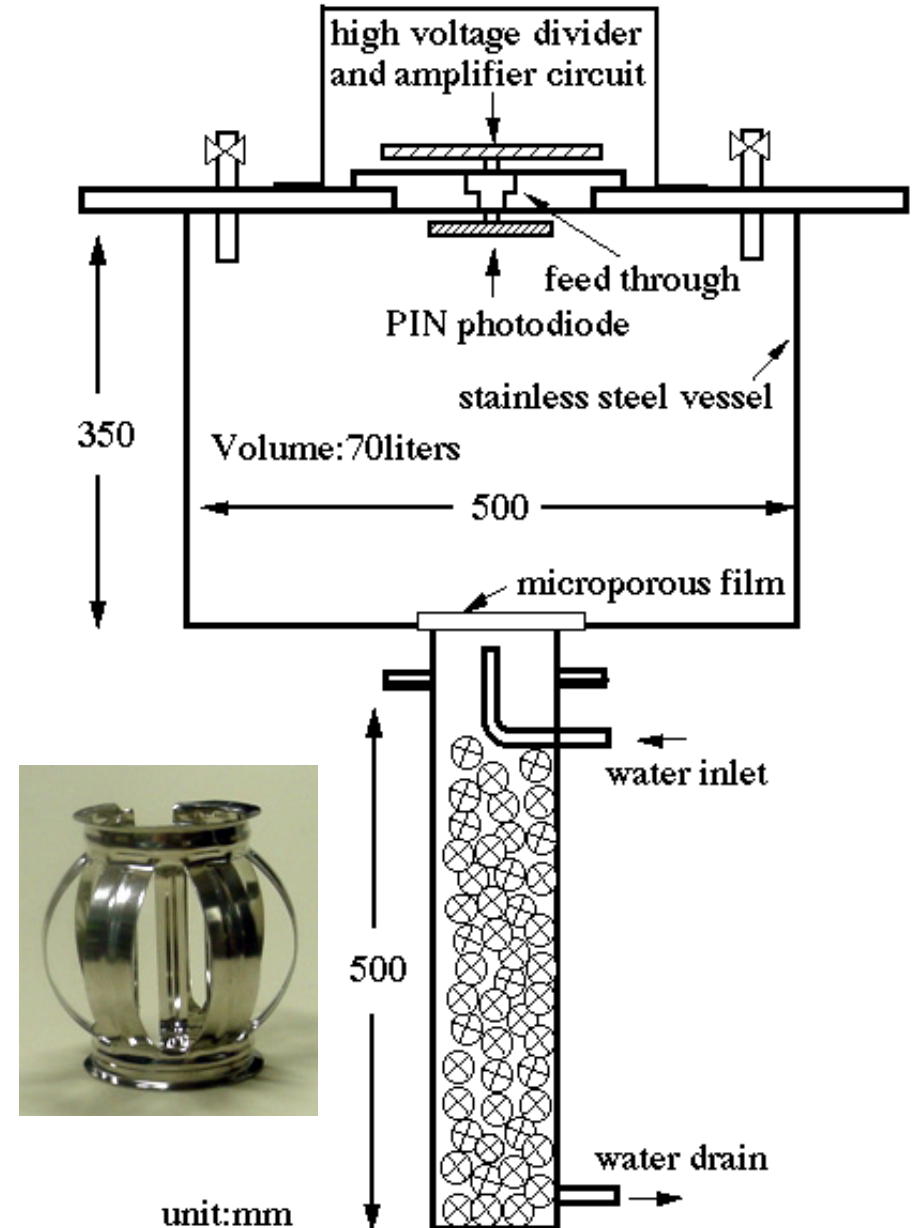
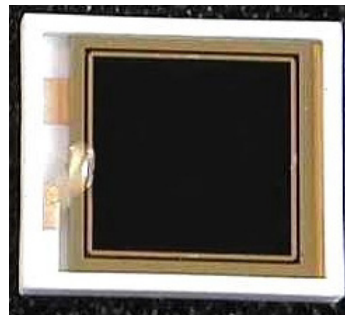
# Observation System in hot spring water

- 16 observation stations in underground water on active faults in Gifu Prefecture, Central part of Japan
- Heisei hot spring (HEI) and Wari-ishi hot spring (KAM)
- High sensitivity radon detector, electromagnetic flow meter and precise thermometer
- Display with the real time in the Web Page



# High Sensitivity Water Radon Detector

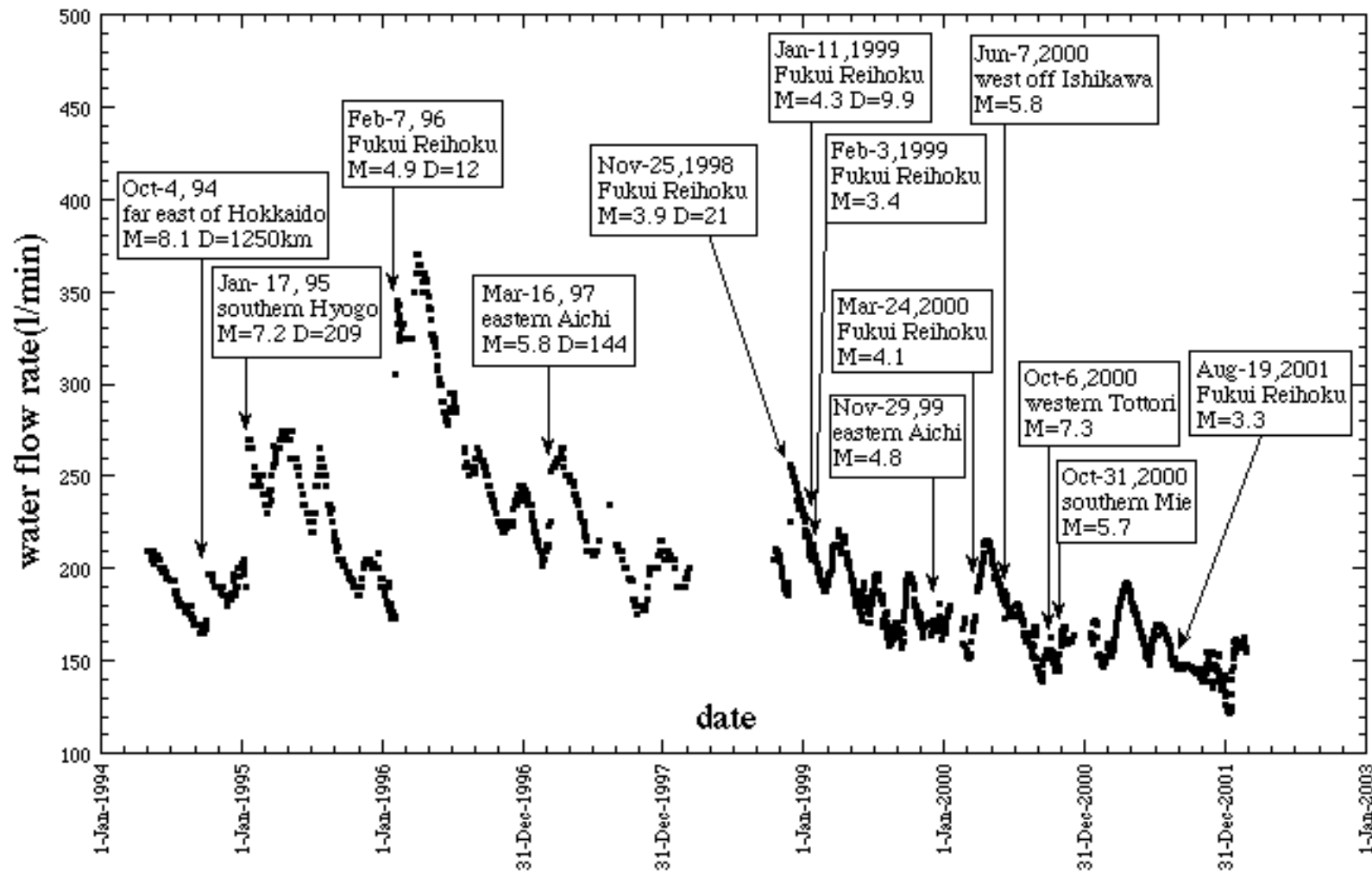
- Gas extraction unit: stainless ball
- Electrostatic collection unit: alpha energy by PIN photodiode
- Sensitivity: improved from the current detector by about 100 times.
- Detection limit:  $0.005\text{Bq/m}^3$



# Heisei hot spring(HEI)

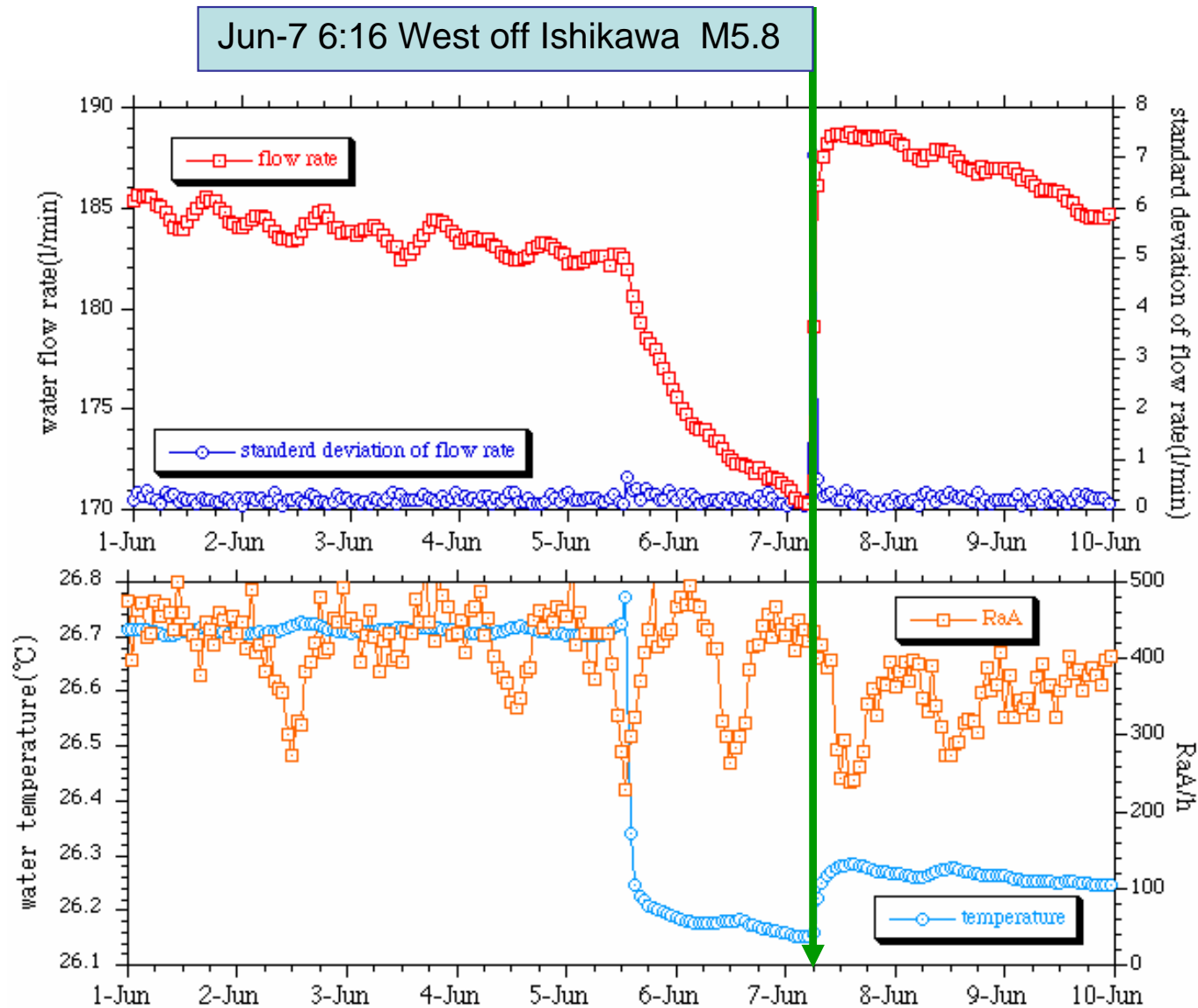
## amount of the hot spring water

- 10 co-seismic changes( $M > 3.0$ ), 2 pre-seismic changes
- November 1998 - December 2002



# Pre-seismic change(HEI)

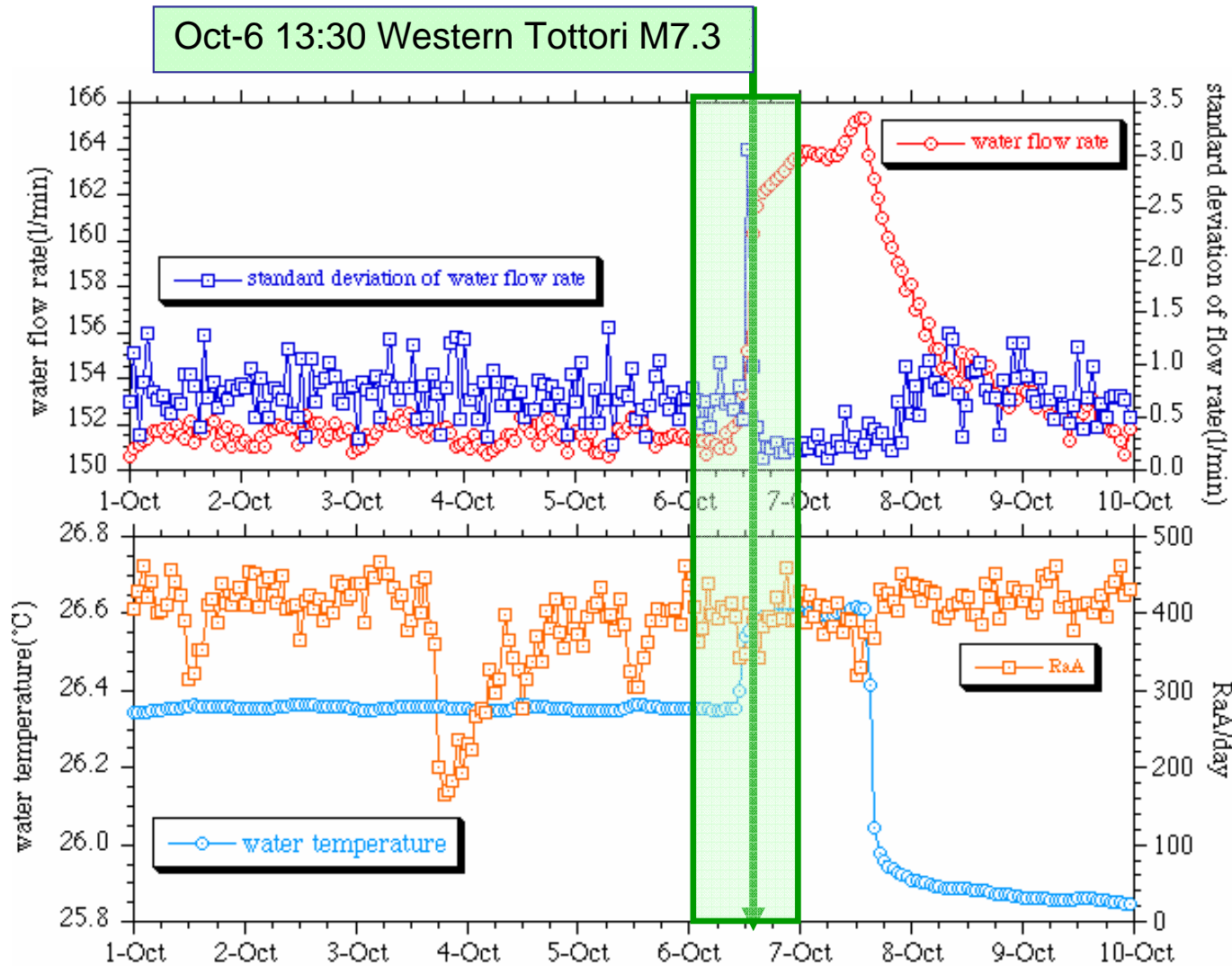
## West off Ishikawa earthquake M5.8, D=120km



- Decrease of water flow rate and temperature before 42 hours

# Pre-seismic change(HEI)

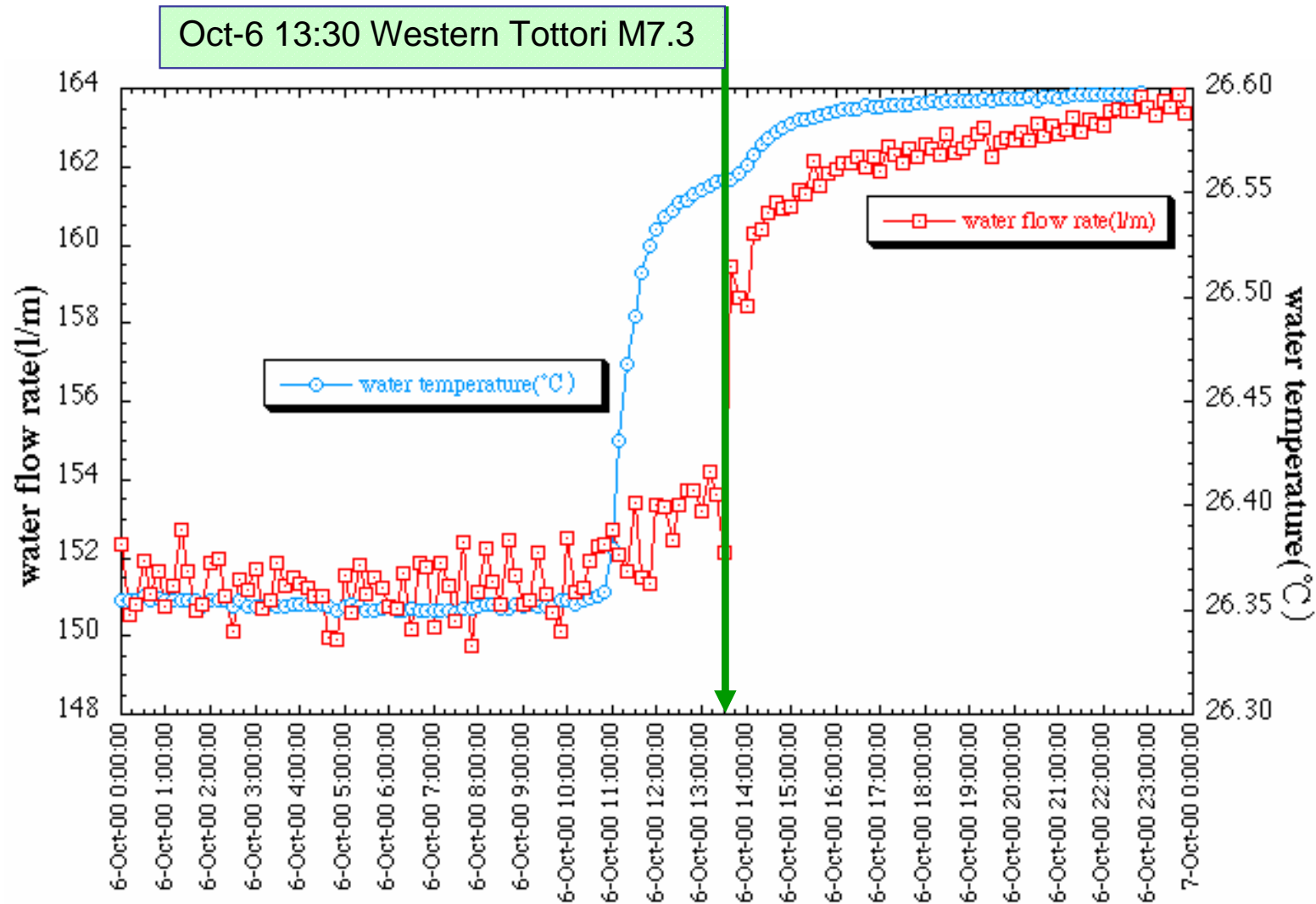
## West Tottori Earthquake M7.3, D=260km



- Increase of water flow rate and temperature before 2.5 hours, and decrease of RaA counts rate. Decrease of deviation of flow rate after earthquake. <sup>6</sup>

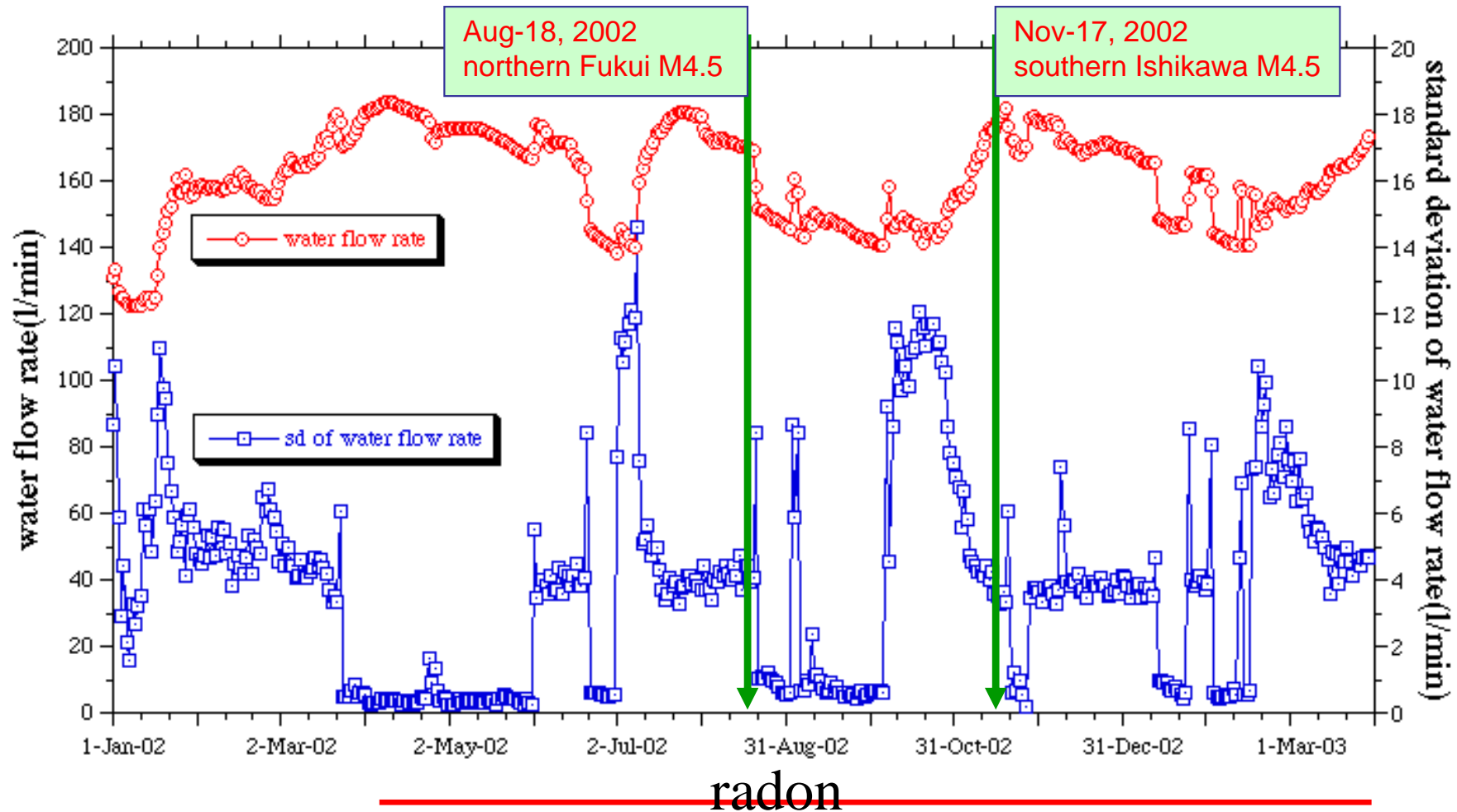
# Pre-seismic change(HEI)

## West Tottori Earthquake M7.3, D=260km



- Increase of water flow rate and temperature before 2.5 hours,

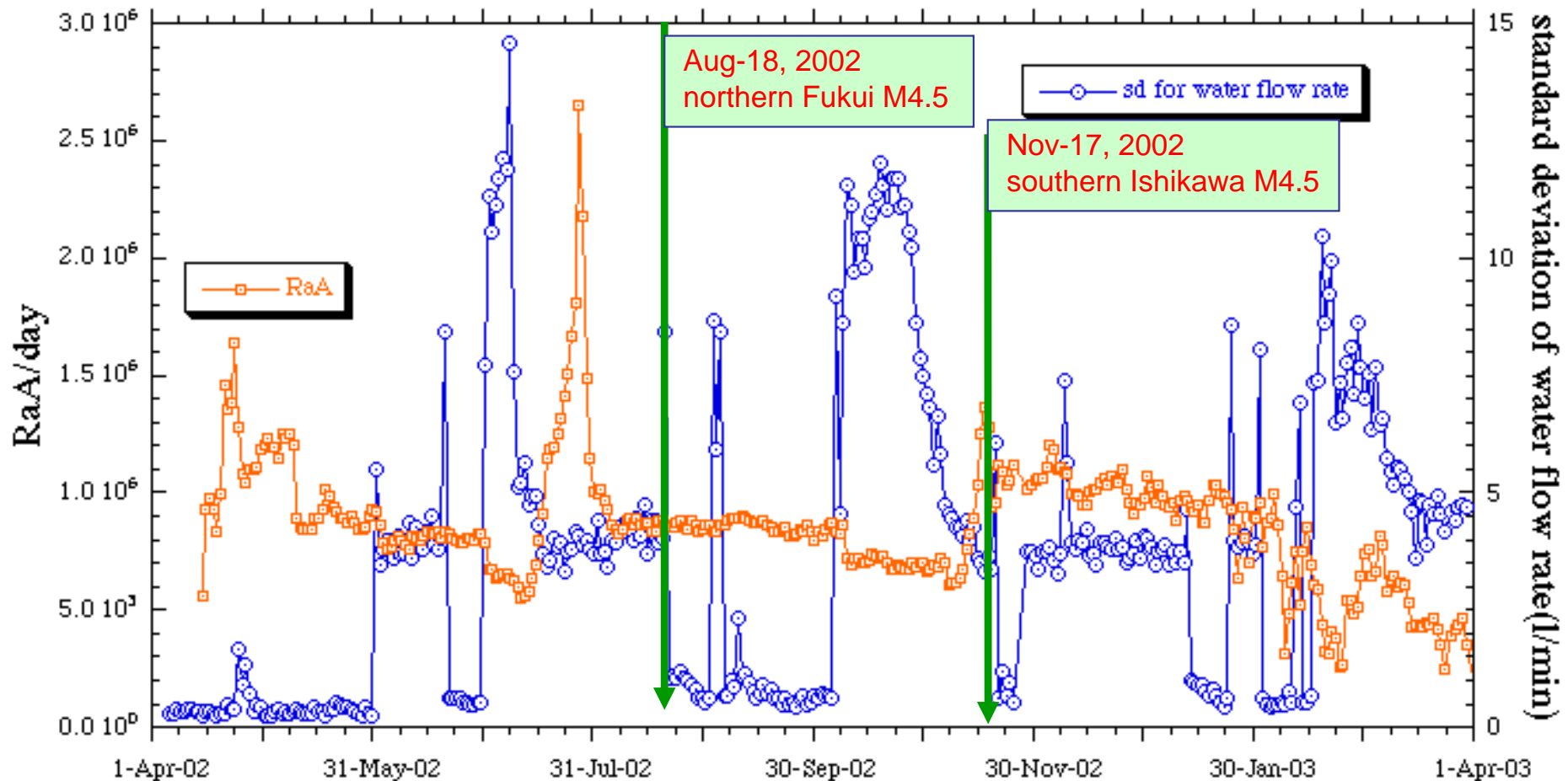
# Amount of gas in hot spring water(HEI)



- Deviation of flow rate proportional to amount of gas in hot spring water
- Maximum period ( $\pm 10$  l/min), middle ( $\pm 4$  l/min) and minimum ( $\pm 0.5$  l/min)
- Maximum period: July 4 to July 19, and Oct 12 to Nov 9, 2002
- Pre-seismic signals before a month
- Two Earthquake: Aug 18 and Nov 17 M4.5, D < 50km



# Radon observation results(HEI)

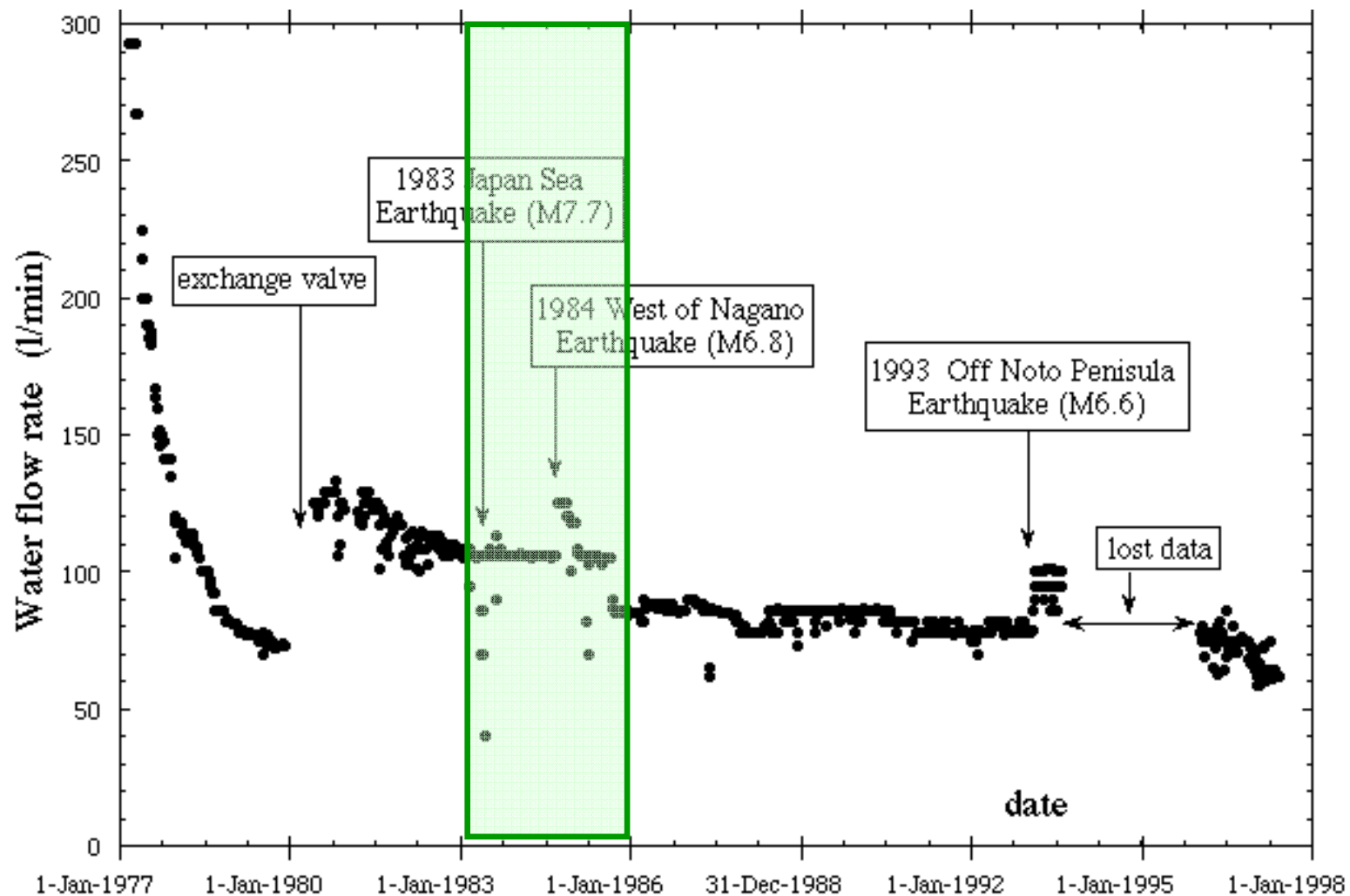


- High sensitivity radon detector in hot spring water
- Maximum period: July 18 to Aug 5, and Nov 10 to Nov 19, 2002
- Pre-seismic signals before a week
- Two Earthquake: Aug 18 and Nov 17 M4.5, D <50km

# Wari-ishi hot spring(KAM)

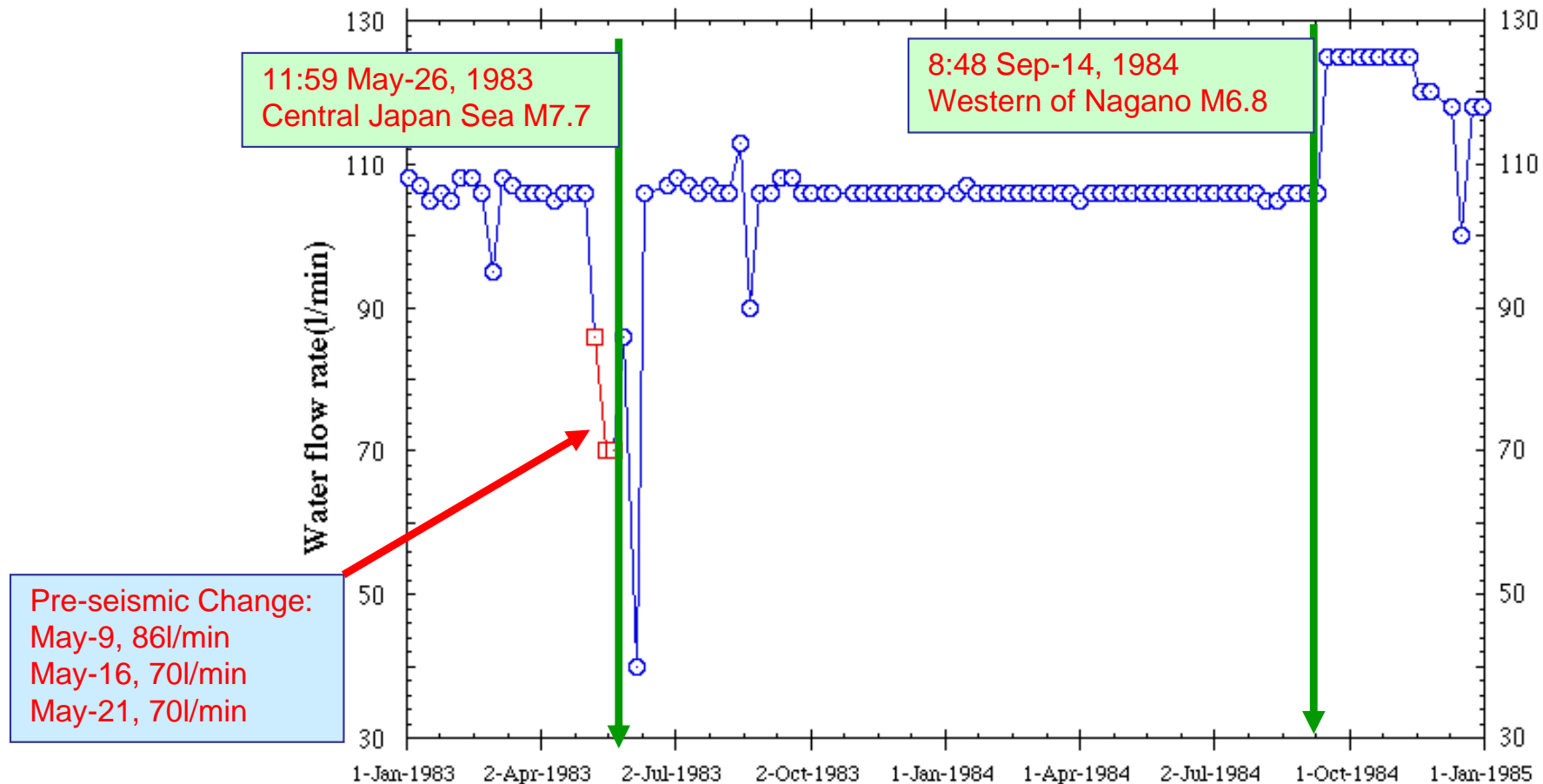
## amount of the hot spring water

- 2 co-seismic changes, a pre-seismic change ( $M > 6.6$ )
- May 1977 - Dec 1997 by persons for maintenance



# Pre-seismic change(KAM)

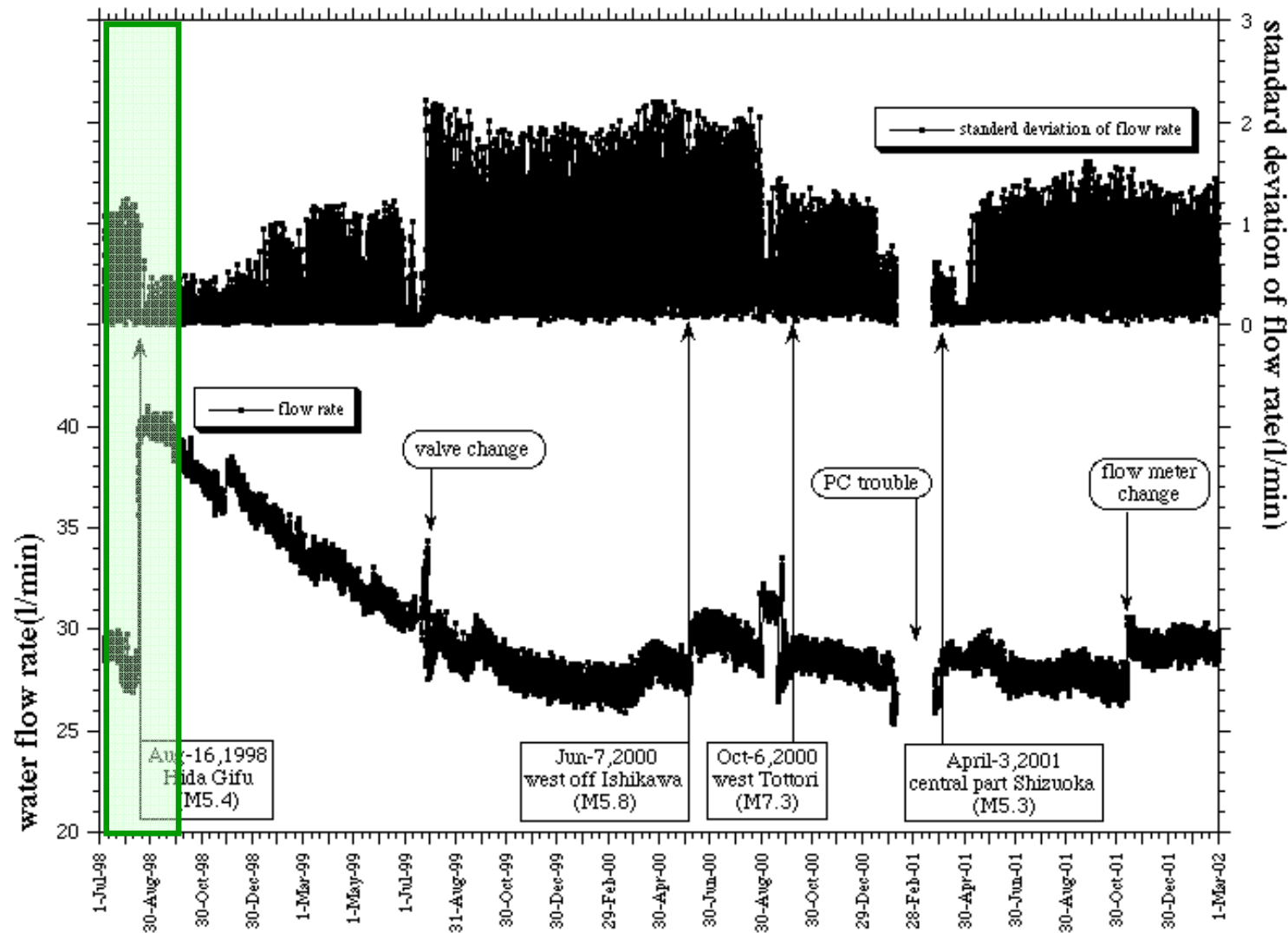
## Central Japan Sea earthquake M7.7, D=470km On 11:59 May 26, 1983



- Decrease of water flow rate by 74% before 3 weeks.
- Earthquake 22:29 May-14 M5.0 before 12 days.

# Wari-ishi hot spring(KAM)

## amount of the hot spring water

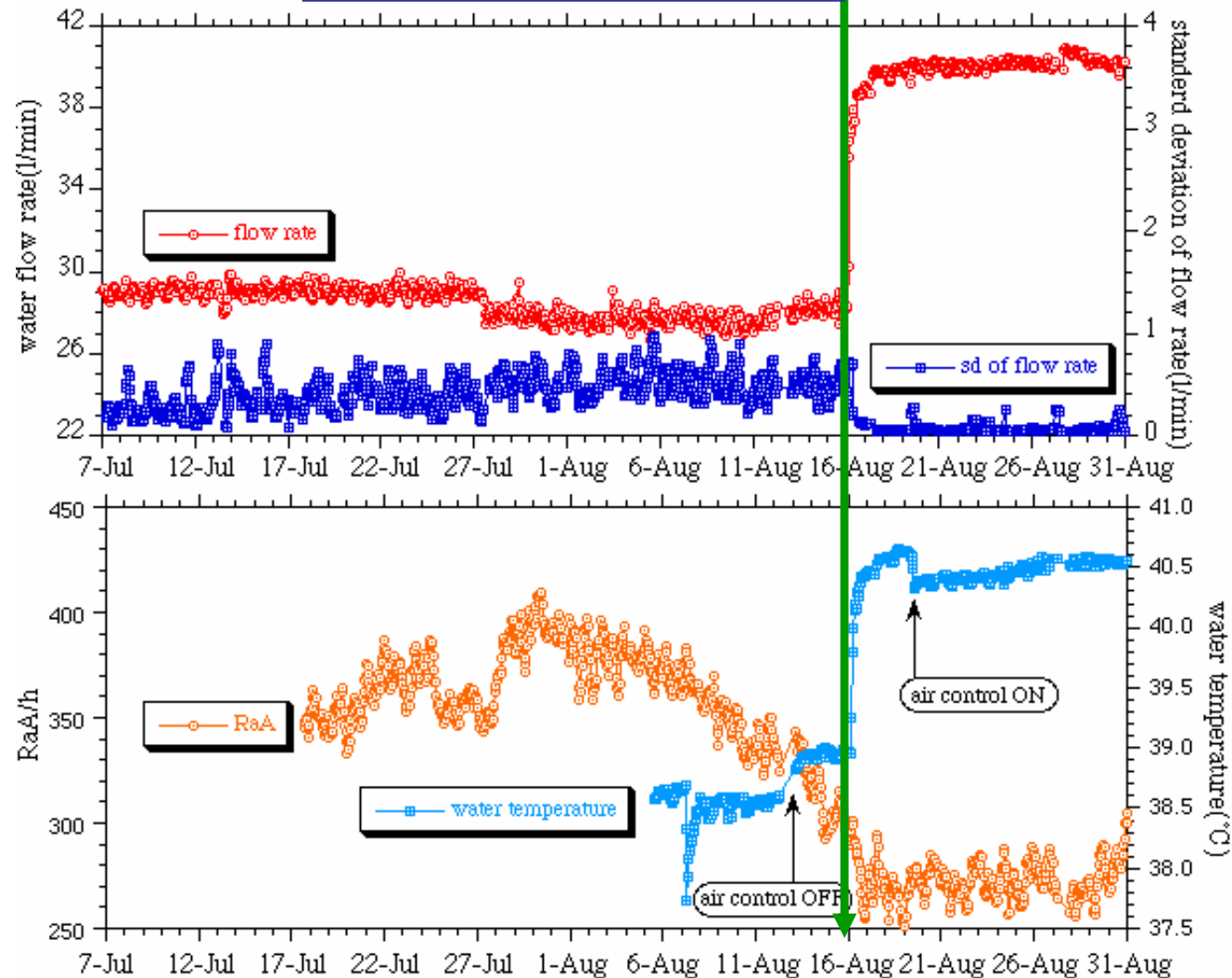


- Co-seismic and pre-seismic change, Jul 1998 - Mar 2002
- Three earthquakes: Pre-seismic changes of amount of the water and gas<sup>12</sup>

# Pre-seismic change(KAM)

## Hida Gifu Earthquake M5.4, D=30km

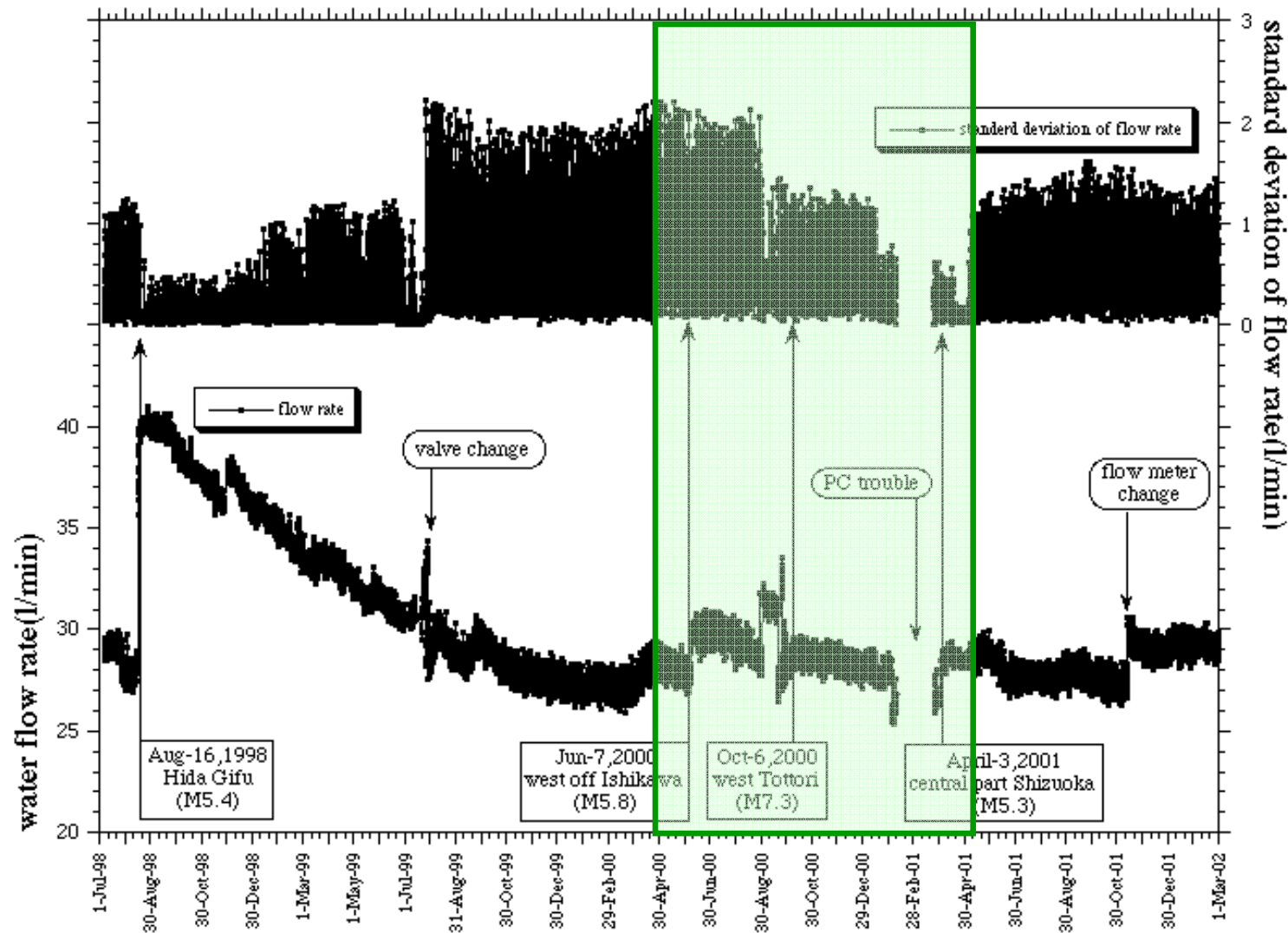
Aug-16 3:31 Hida Gifu M5.4



- Decrease of water flow rate and temperature, and RaA counts rate before 3 weeks. Increase of deviation of flow rate before earthquake.

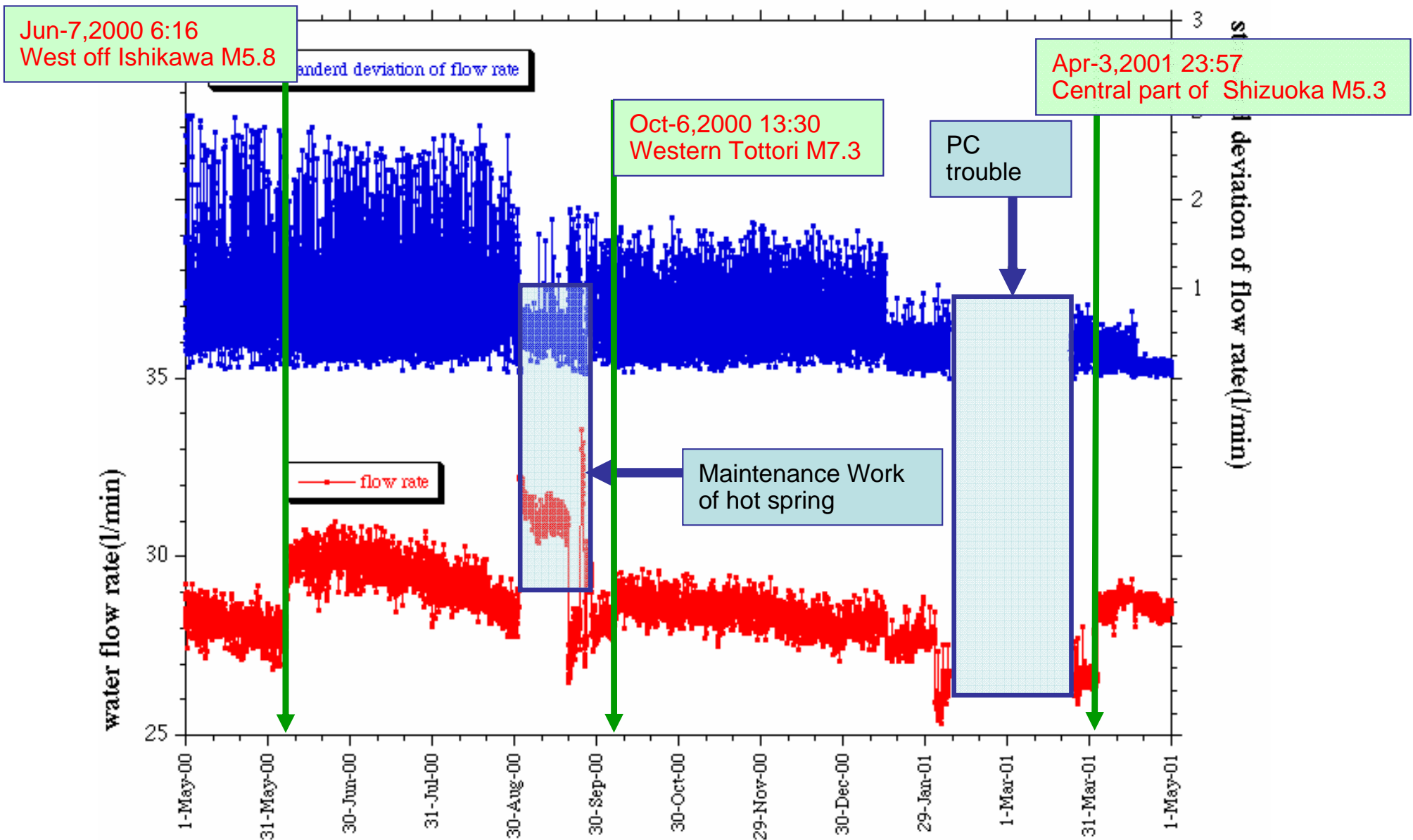
# Wari-ishi hot spring(KAM)

## amount of the hot spring water



- Co-seismic and pre-seismic change, Jul 1998 - Mar 2002
- Three earthquakes: Pre-seismic changes of amount of the water and gas<sup>14</sup>

# Pre-seismic change of the amount of gas (KAM)



- Decrease of standard deviation of flow rate before the Western Tottori Prefecture earthquake and Central part of Shizuoka Prefecture earthquake.<sup>15</sup>

# Summary

- 16 observation stations in Gifu Prefecture, Center Part of Japan from August 1998
- Radon concentration, Flow rate and the standard deviation, Temperature in the hot spring water
- Many co-seismic and 3 pre-seismic changes at Heisei hot spring and Wari-ishi hot spring
- Heisei hot spring:
  - West off Ishikawa M5.8, D=120km before 42hours
  - Western Tottori M7.3, D=260km before 2.5 hours
- Wari-ishi hot spring:
  - Hida Gifu Earthquake M5.4 D=30km before 3 weeks
- Amount of Water and Gas in hot spring water : important signals for the earthquake pre-seismic changes



# Summary of pre-seismic changes

earthquake	date	D	pre-seismic changes	time	site
Central Japan Sea M7.7	May 26,1983	470km	F: 107->70(l/min)	3 weeks	KAM
Hida Gifu M5.4	Aug 16, 1998	30km	F: 29->27(l/min) Rn: 400->280(RaA/h)	3 weeks	KAM
West off Ishikawa M5.8	Jun 7, 2000	120km	F: 183->170(l/min) T: 26.7->26.2(deg)	42 hours	HEI
Western Tottori M7.3	Oct 6, 2000	260km	F: 151.5->153.5(l/min) T: 26.35->26.56(deg)	2.5 hours	HEI

- F: water flow rate(l/min), Rn:number of RaA counts(RaA/h),  
T: water temperature(deg)
- KAM:Wri-ishi hot spring, HEI:Heisei hot spring
- 1st line data by Kamioka-Town office persons