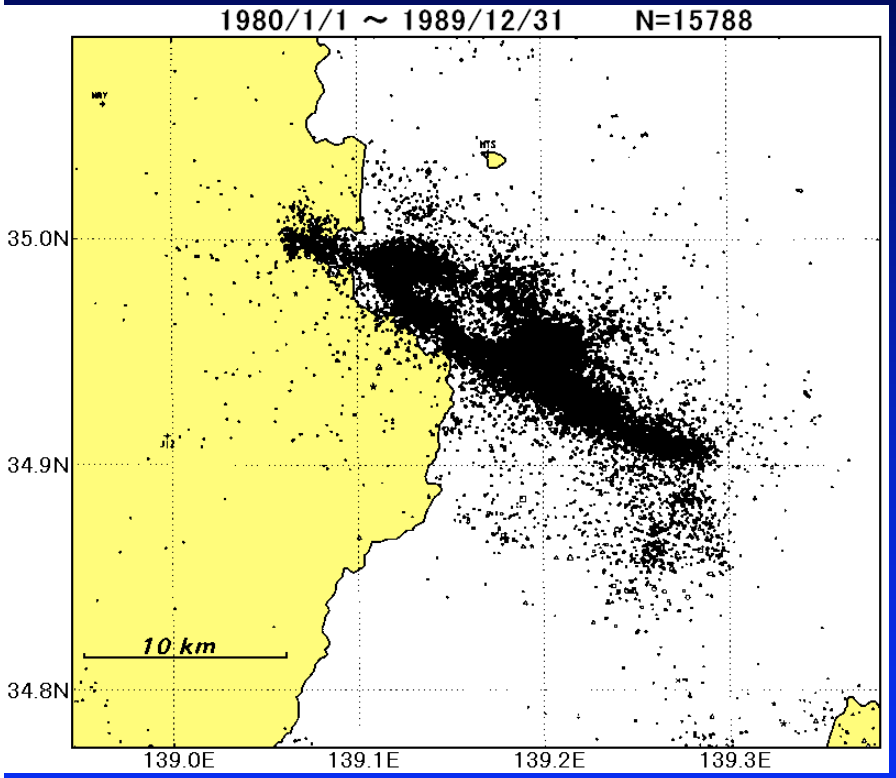
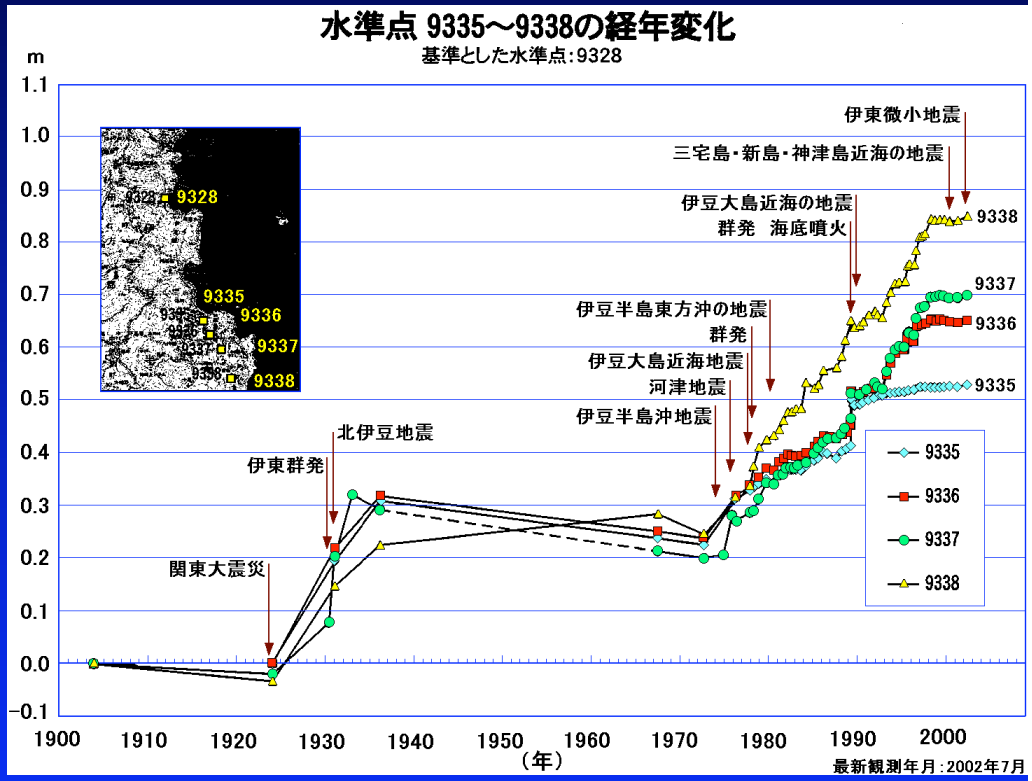
Recurrence of earthquake swarms off eastern Izu Peninsula, central Japan





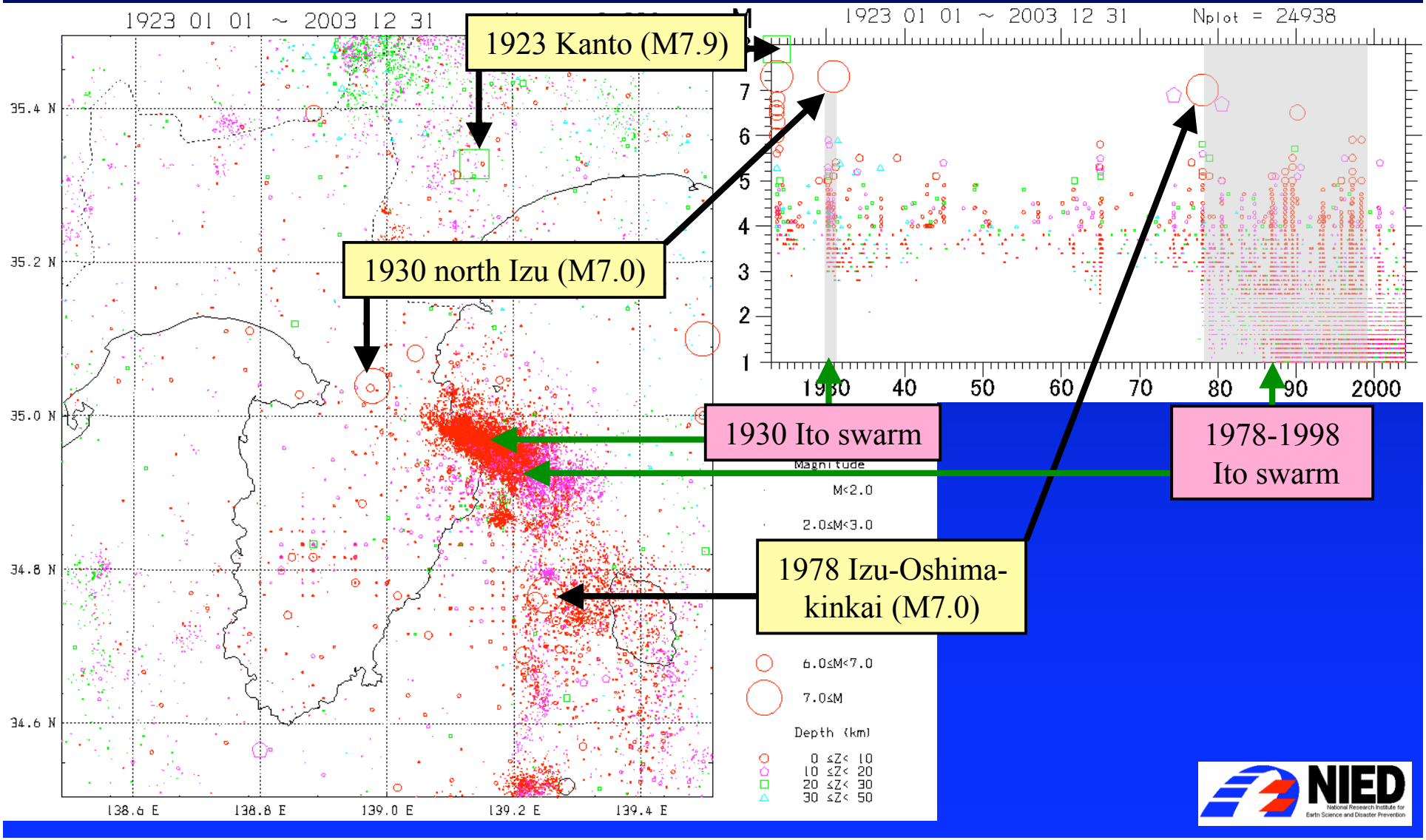
Yoshimitsu Okada

(National Research Institute for Earth Science and Disaster Prevention, Japan)

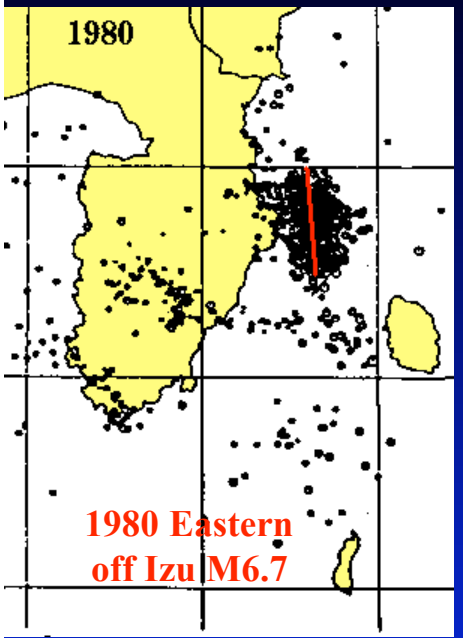
2004.10.14 5th UJNR Earthquake Research Panel at Monterey

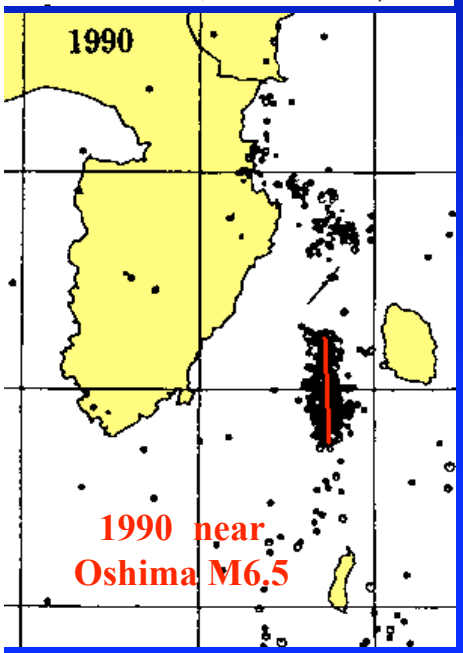
Long term seismic activity around Izu Peninsula

1923～2003（JMA）



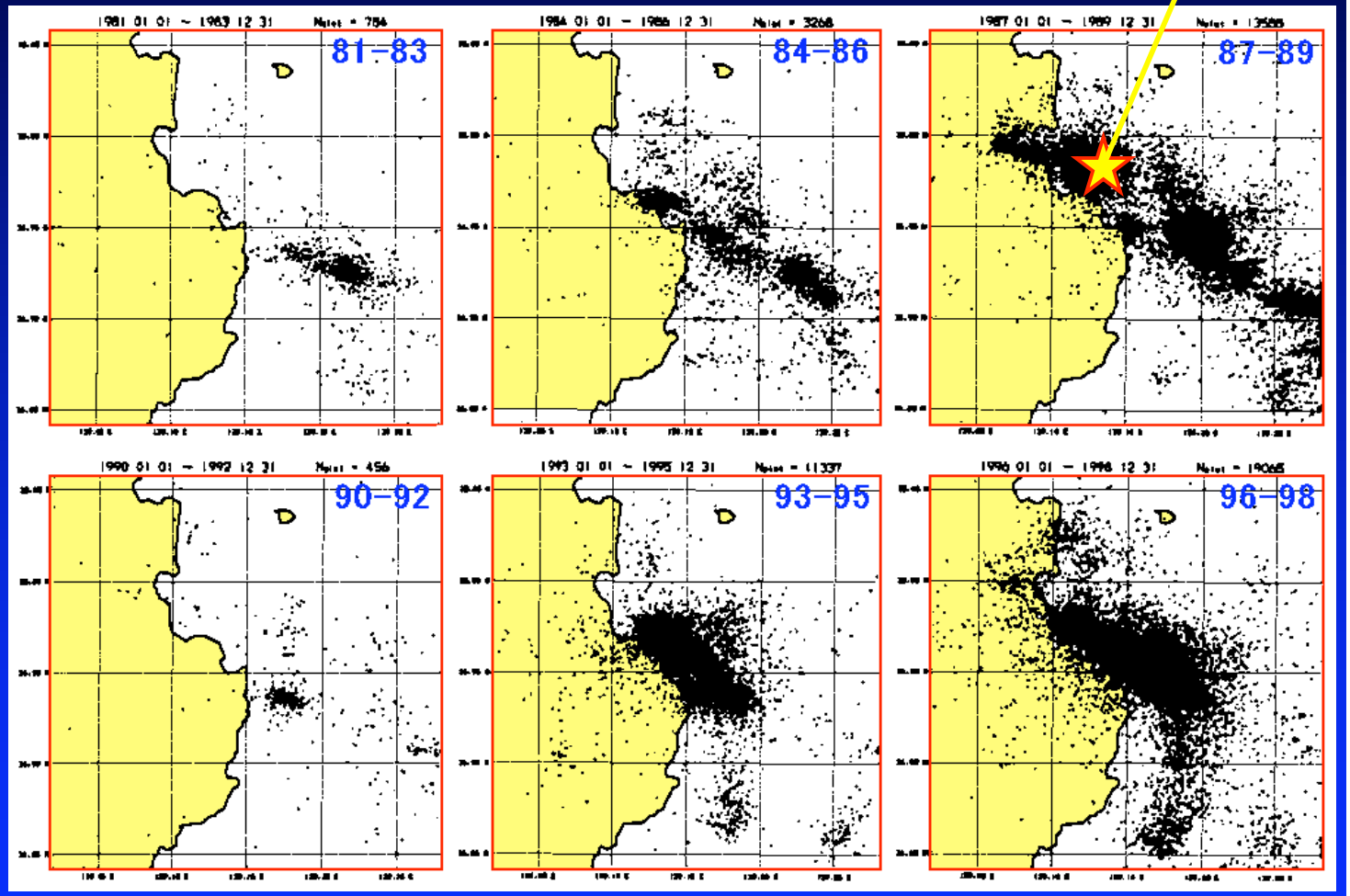
Seismic activity in 1980-1998





Swarms at eastern off Izu Peninsula

submarine eruption



(Okada and Ishii, 2000)

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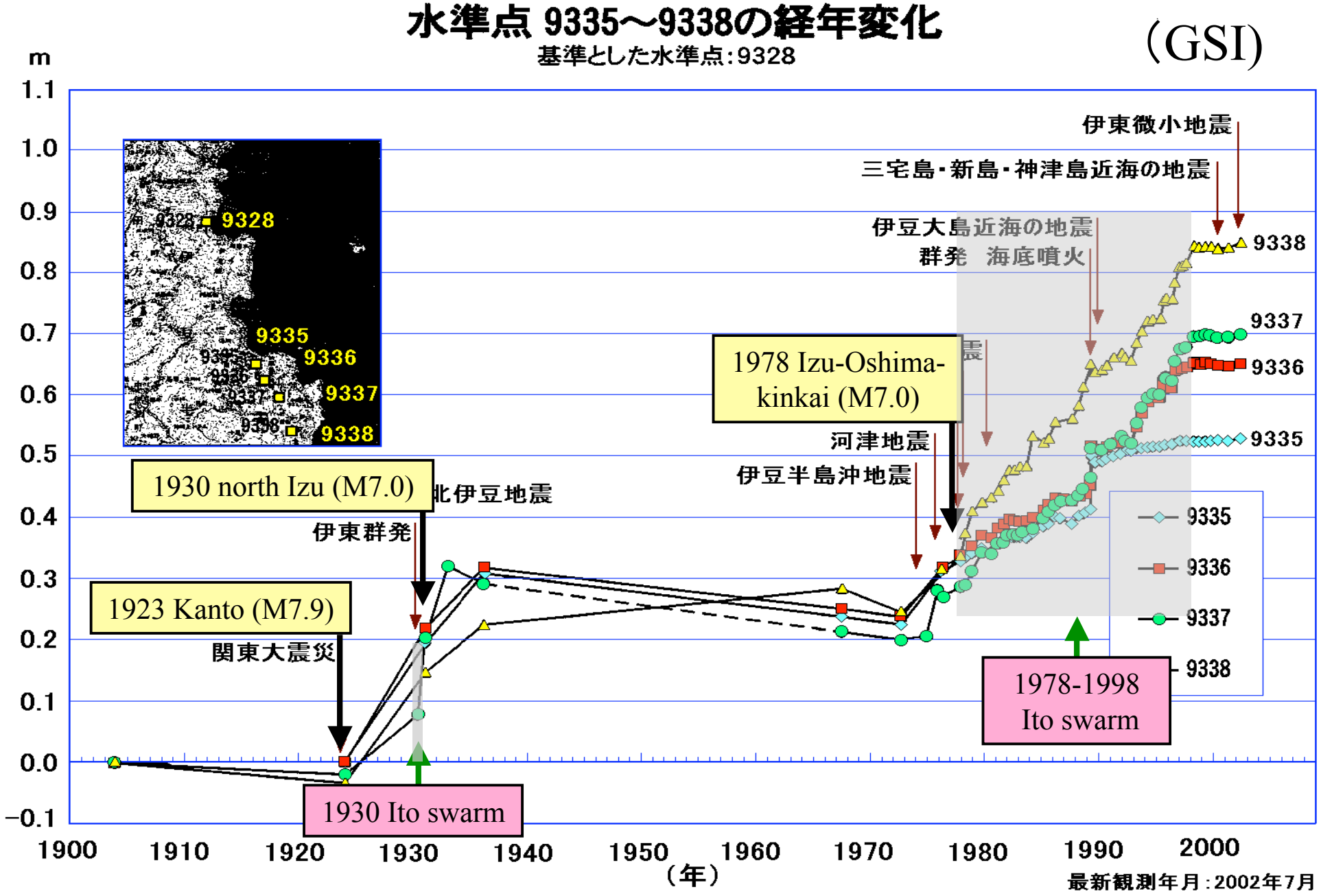
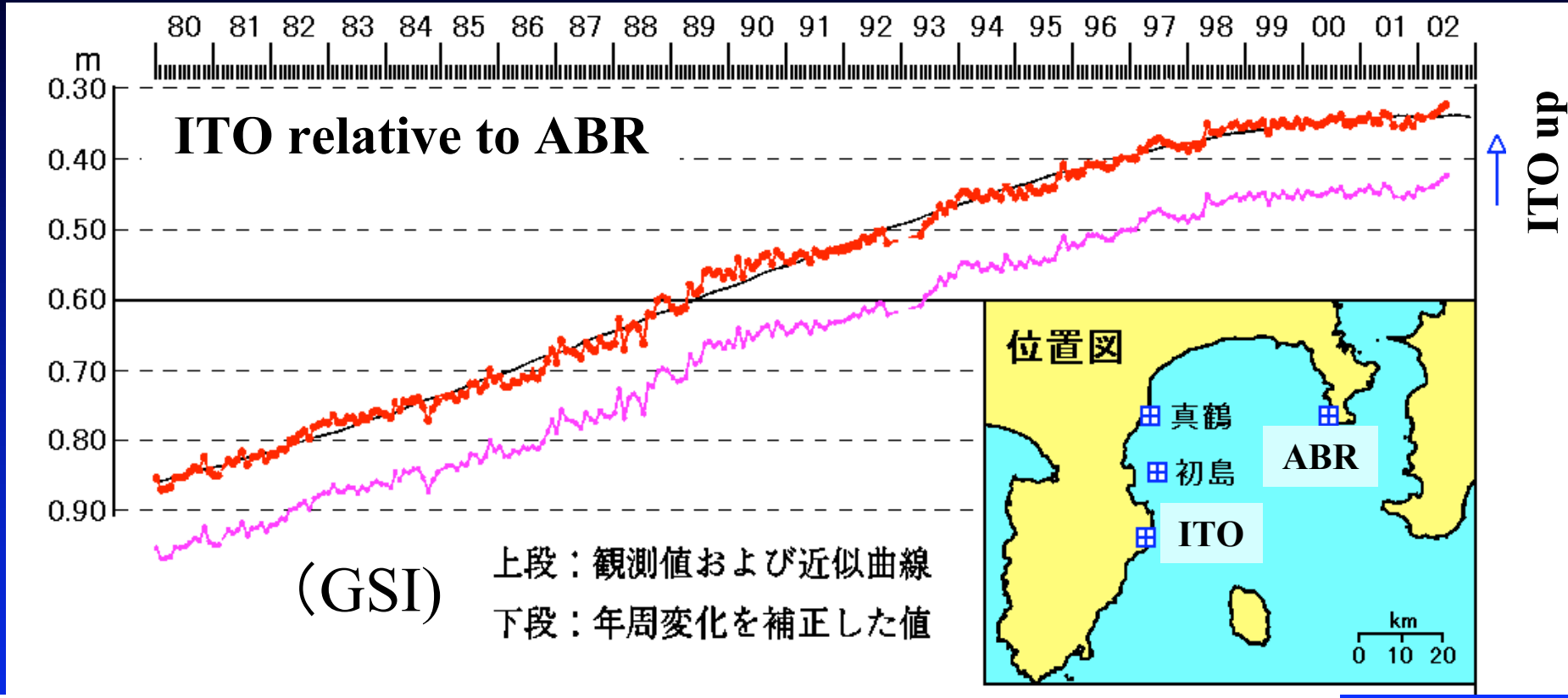
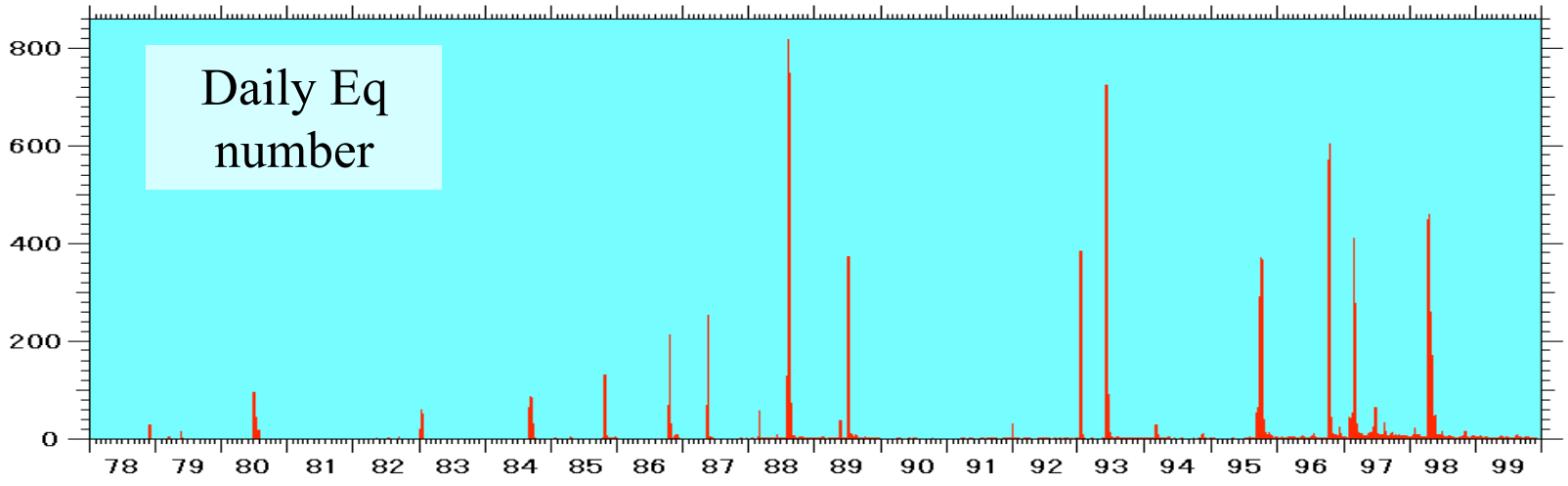
Long term crustal deformation around Ito (leveling)

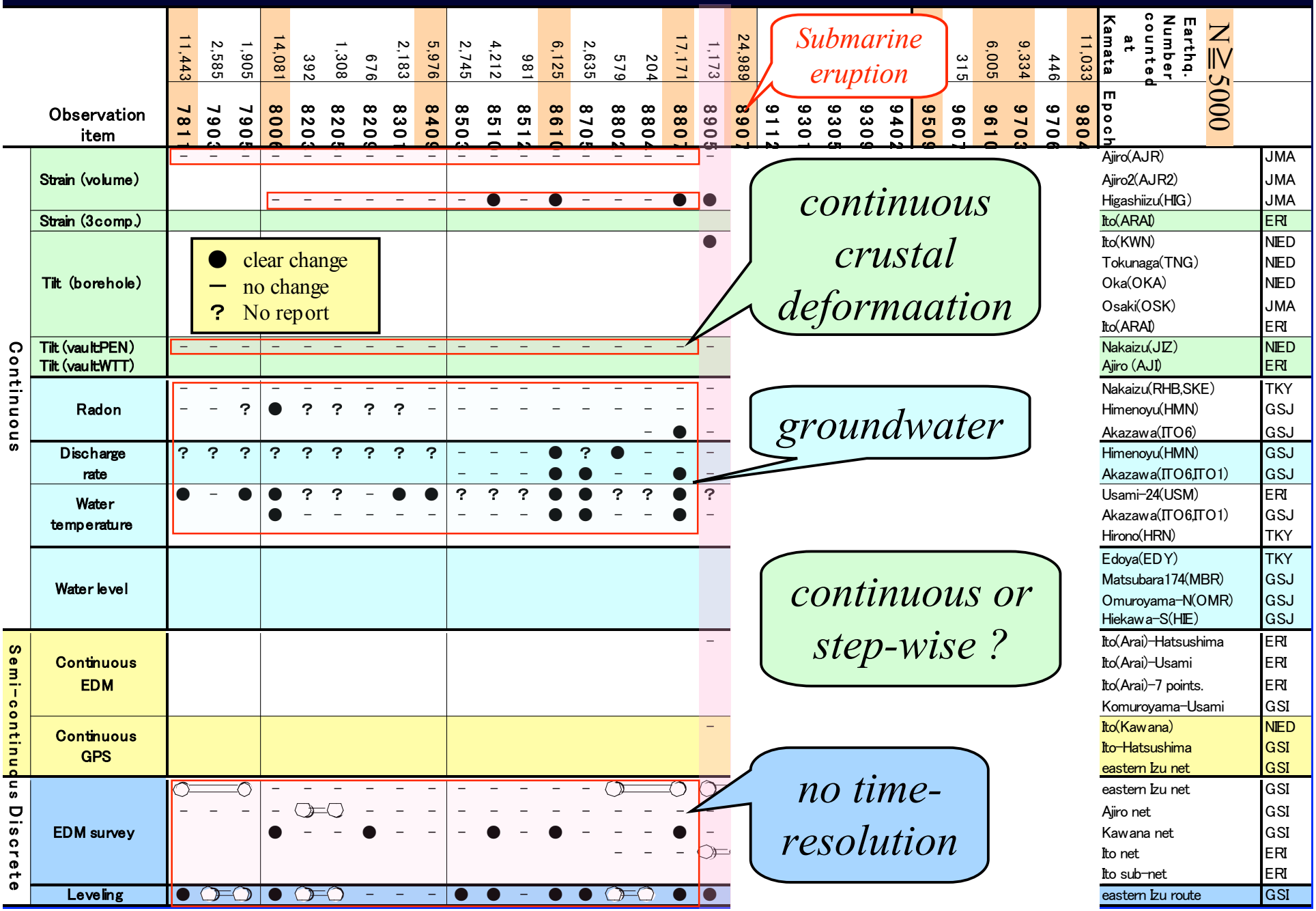


Crustal deformation in 1980-2002 (tidal observation)

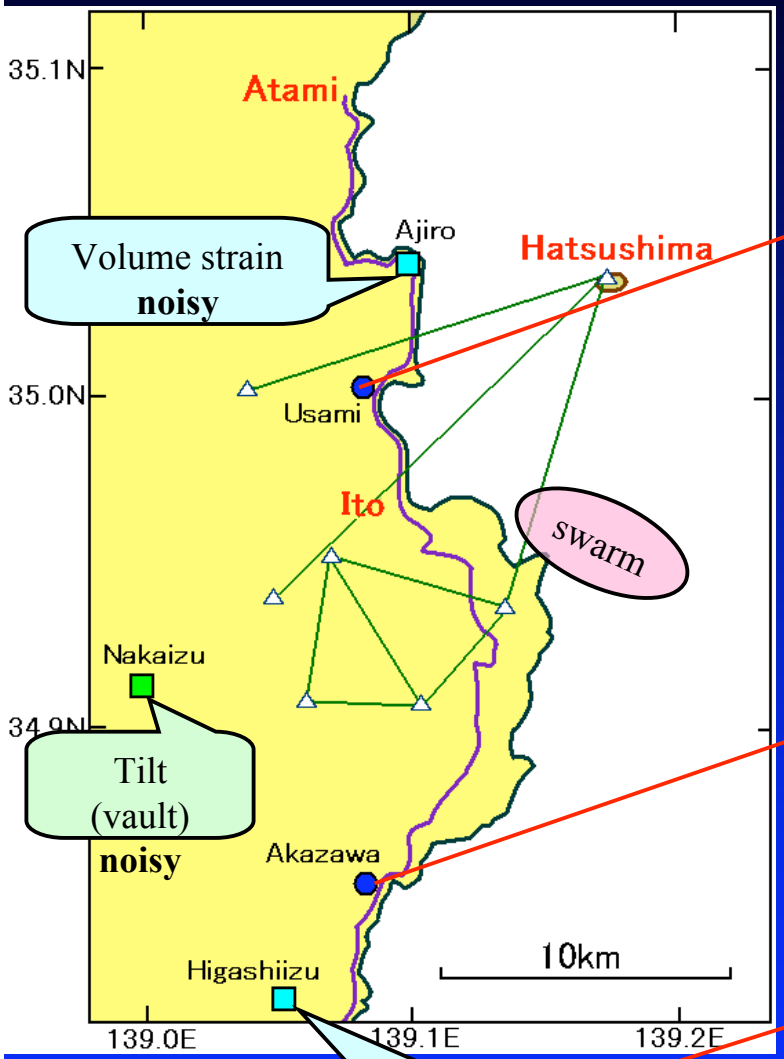




Crustal deformation associated to swarm



Before 1989

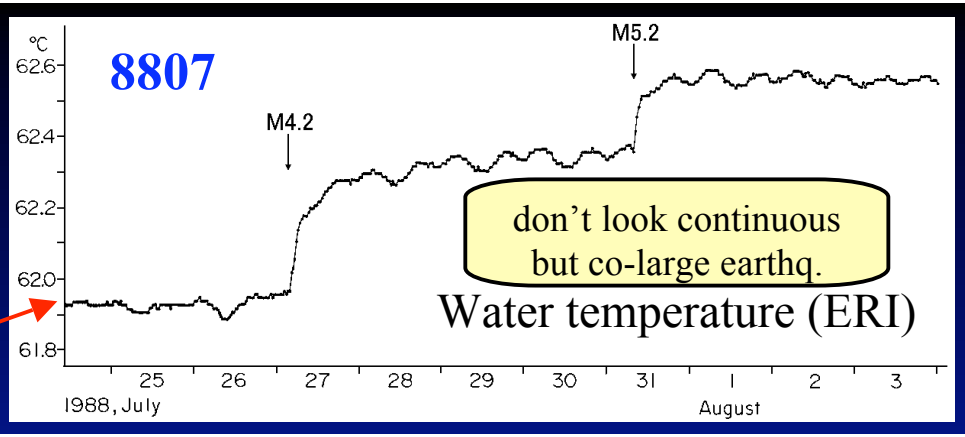


Volume strain **noisy**

Tilt (vault) **noisy**

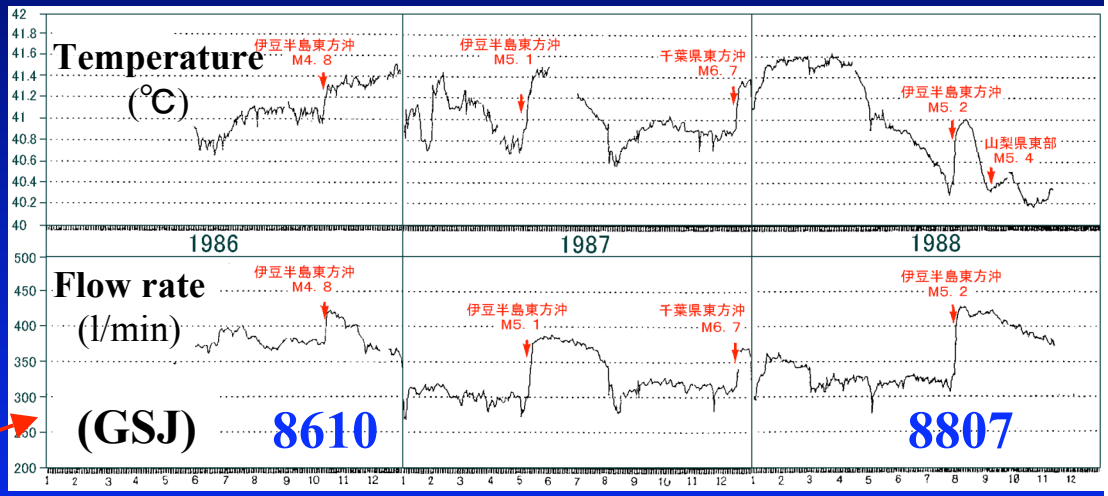
Volume strain

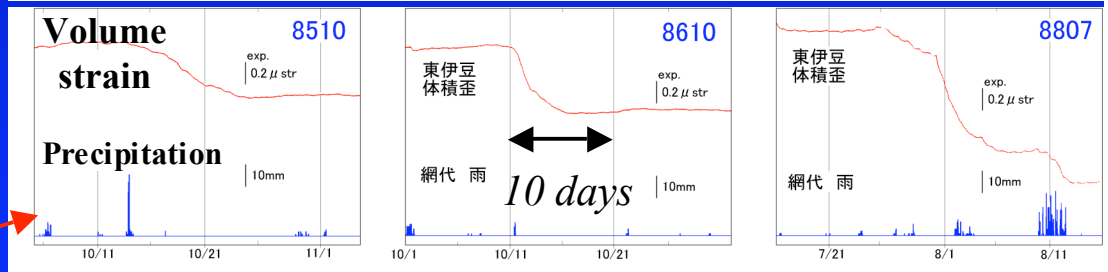
(?) only 1-station, 1-component
(?) contaminates with rainfall effect
(?) large signal compared to distance

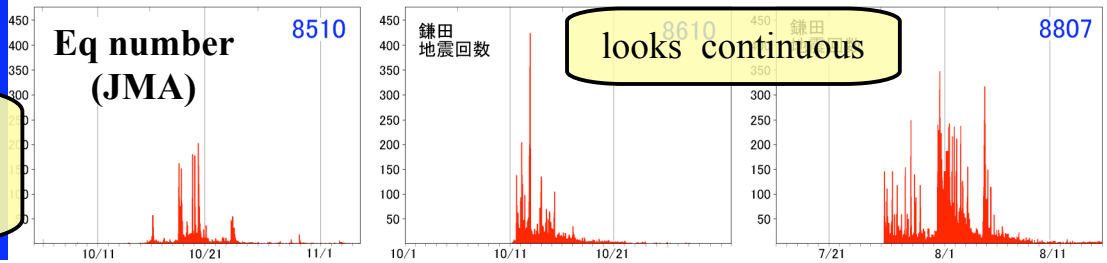


don't look continuous but co-large earthq.

Water temperature (ERI)

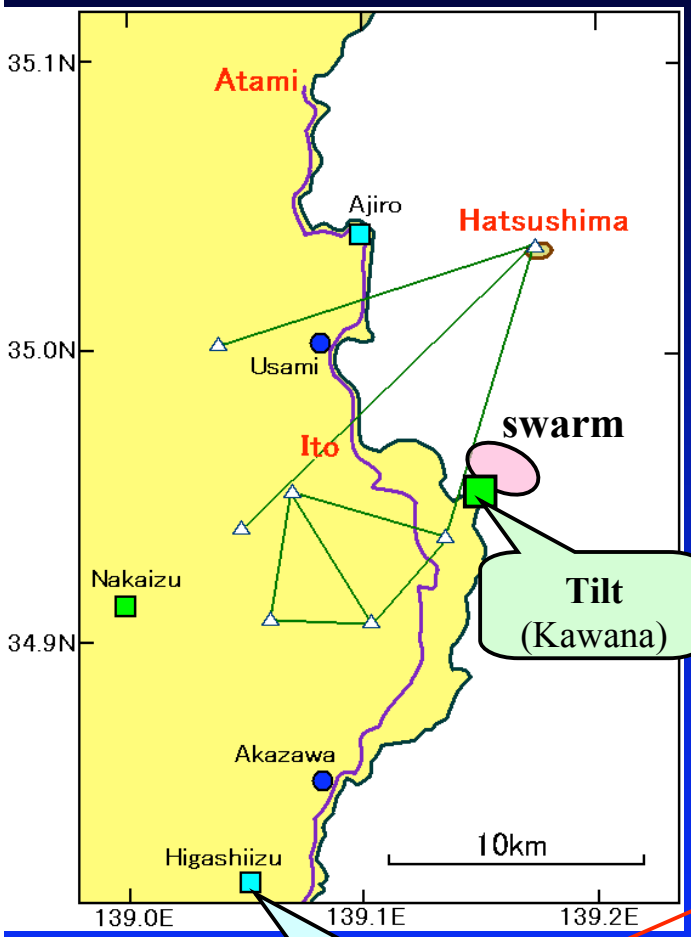






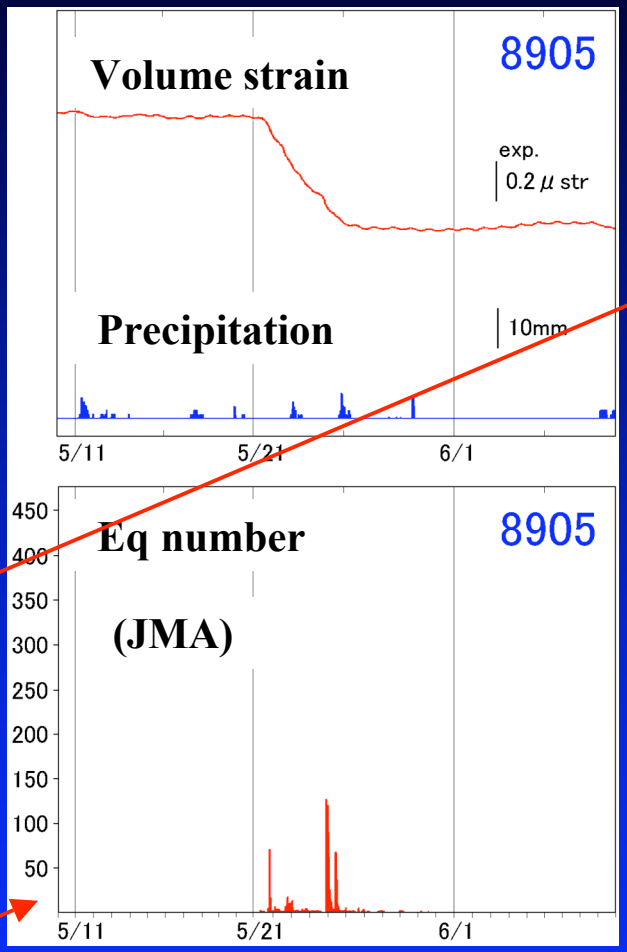
looks continuous

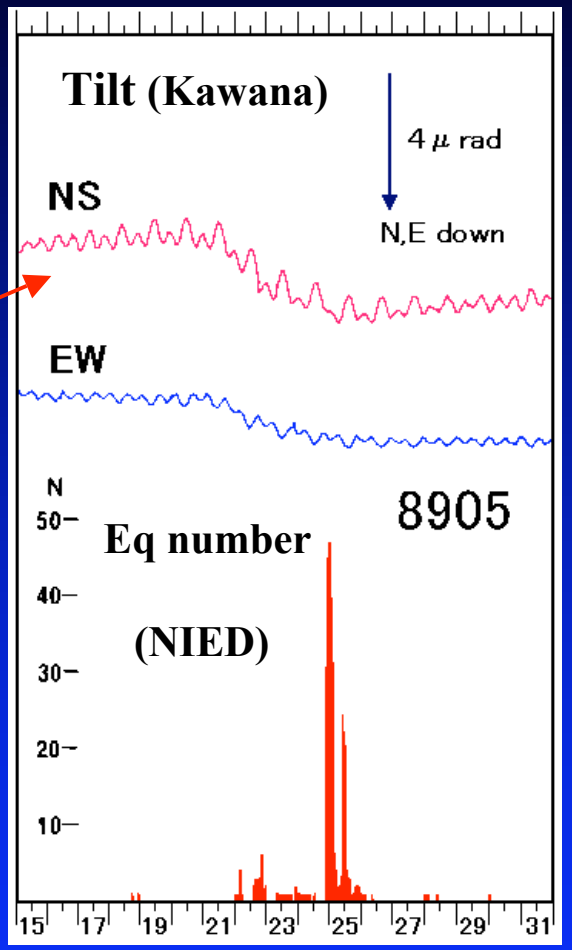
A minor swarm in May 1989



Tilt (Kawana)

Volume strain (Higashiizu)





- 2-stations, multi-components
- changed simultaneously

⇒ **real co-swarm signal**

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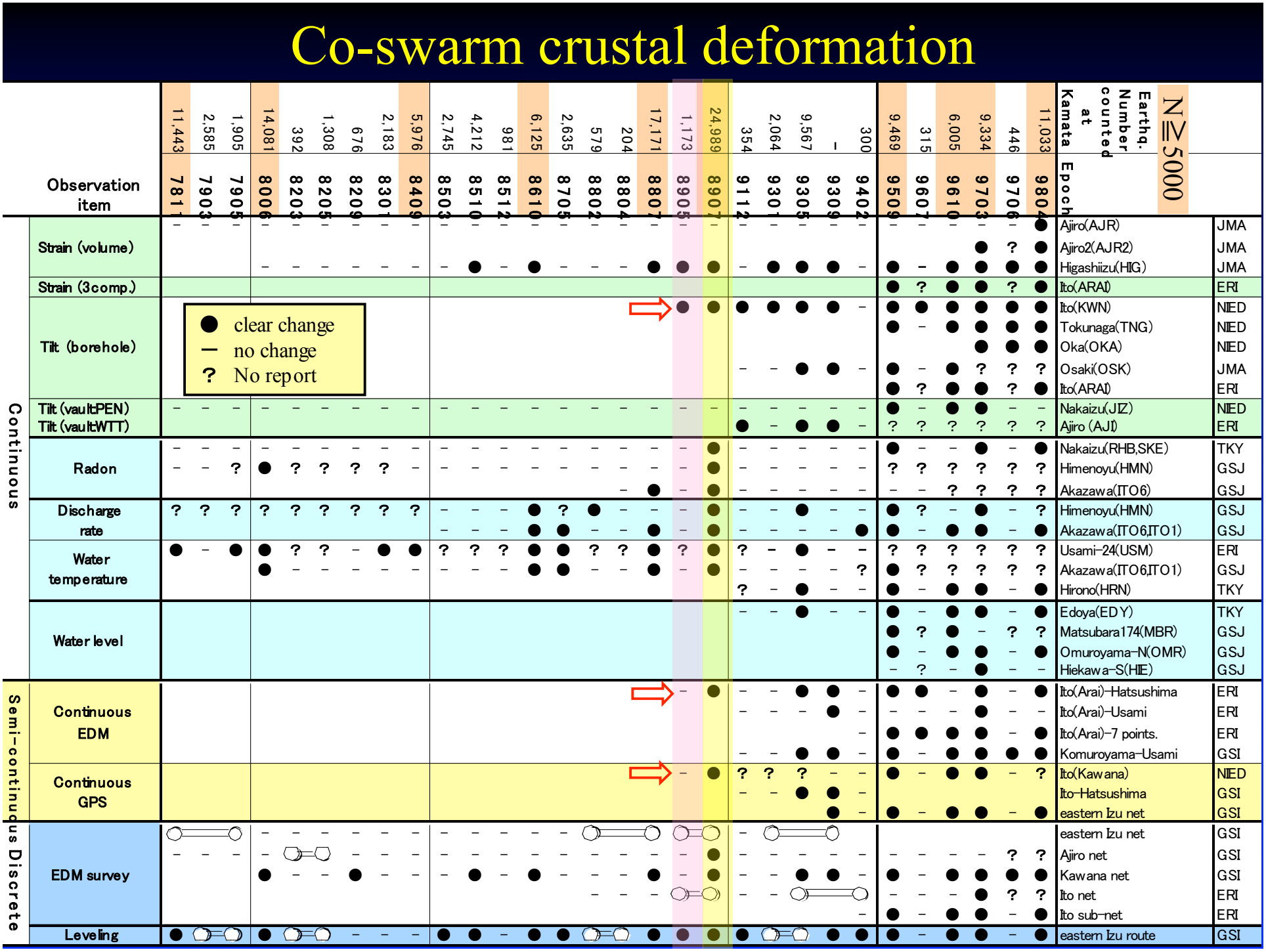
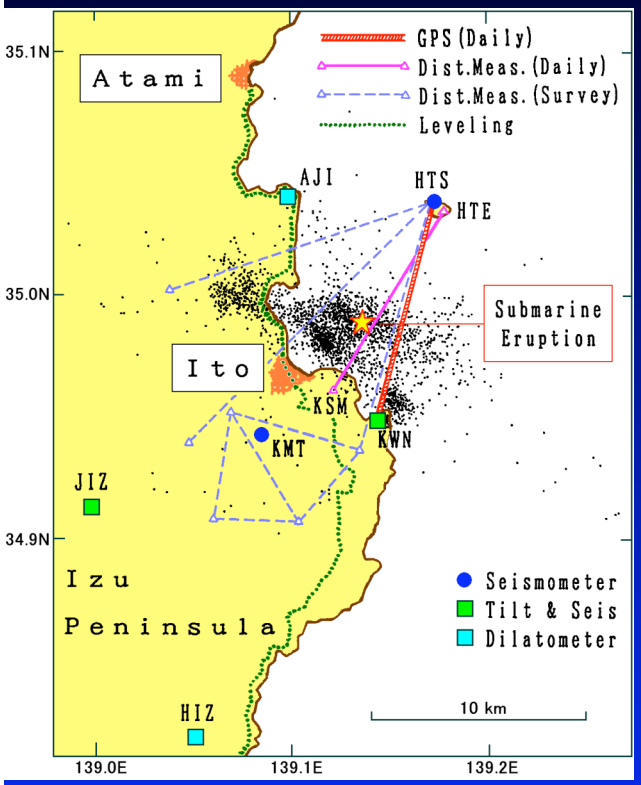
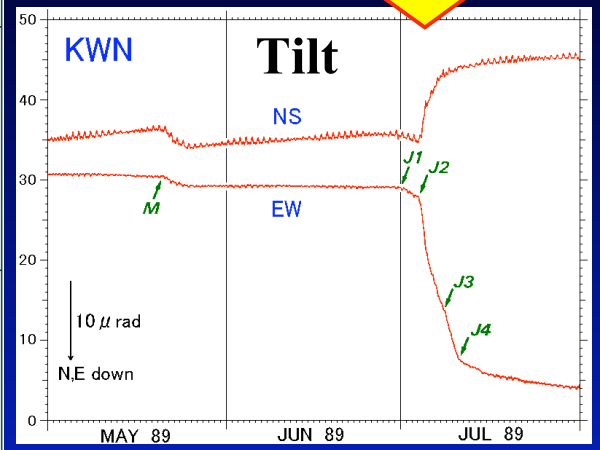
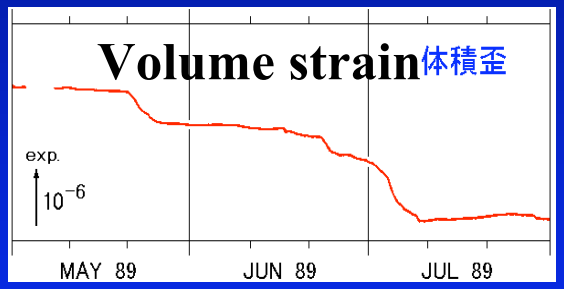
Co-swarm crustal deformation

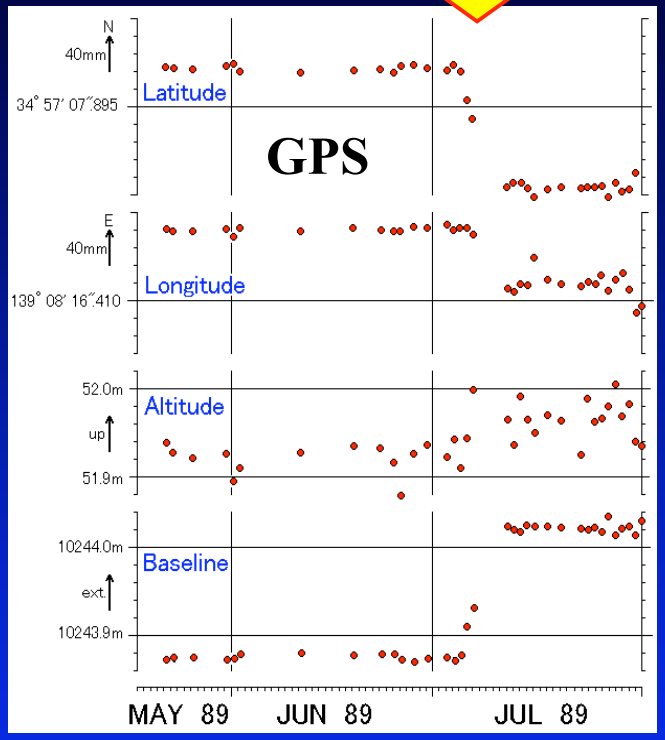


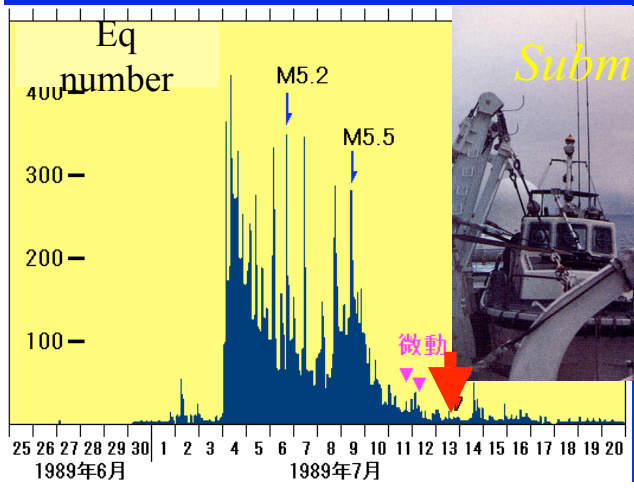
A major swarm in July 1989

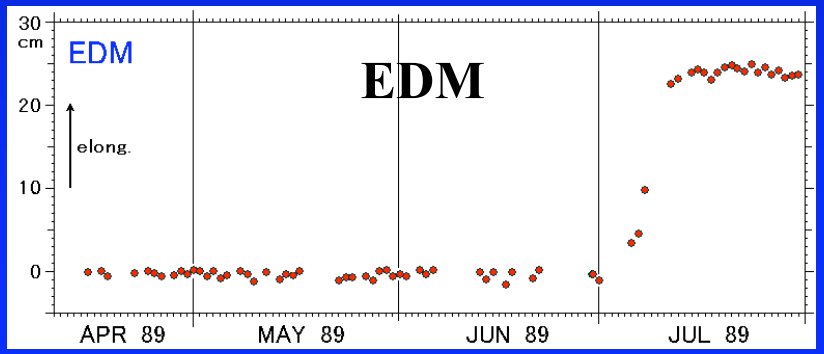












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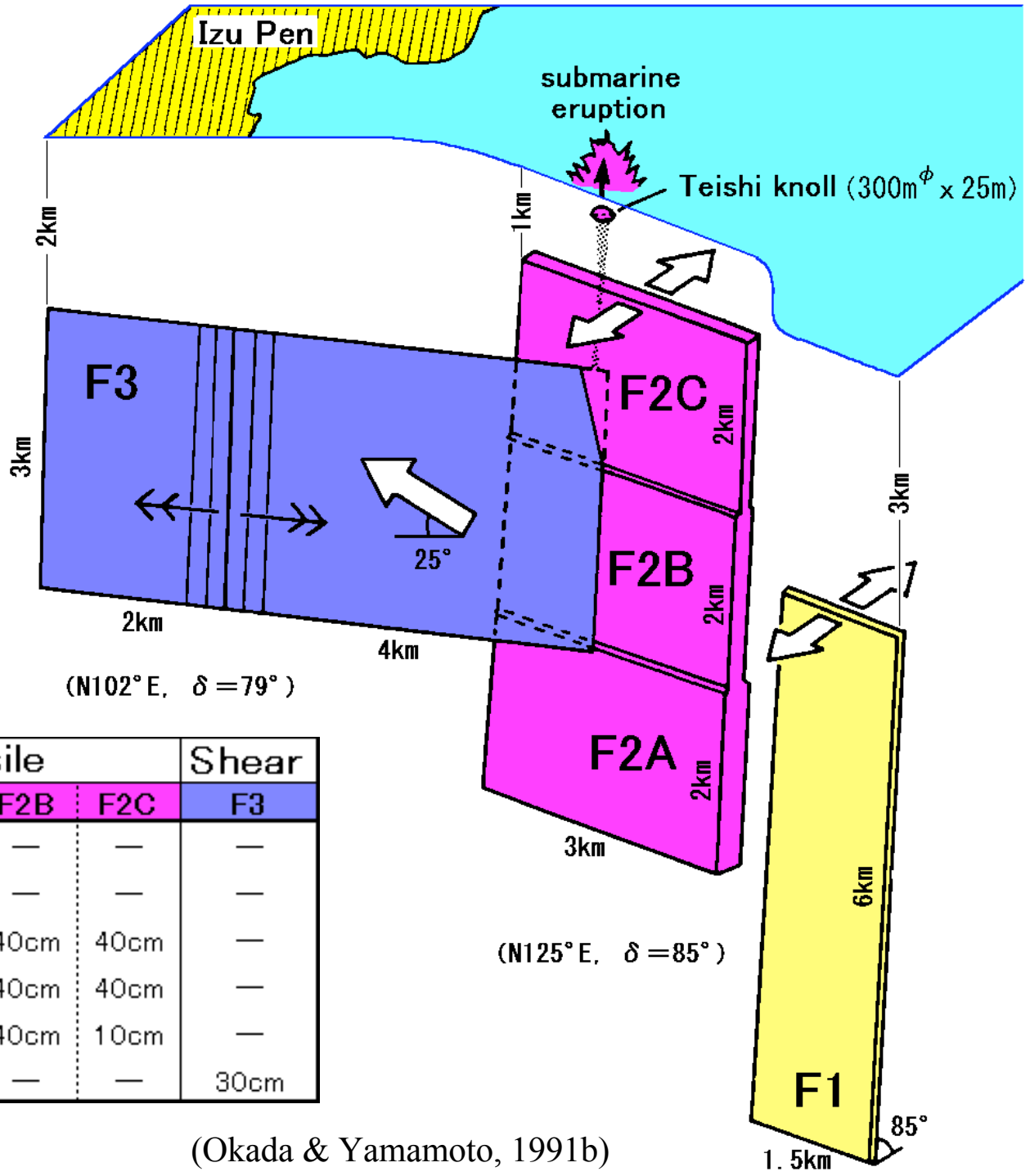
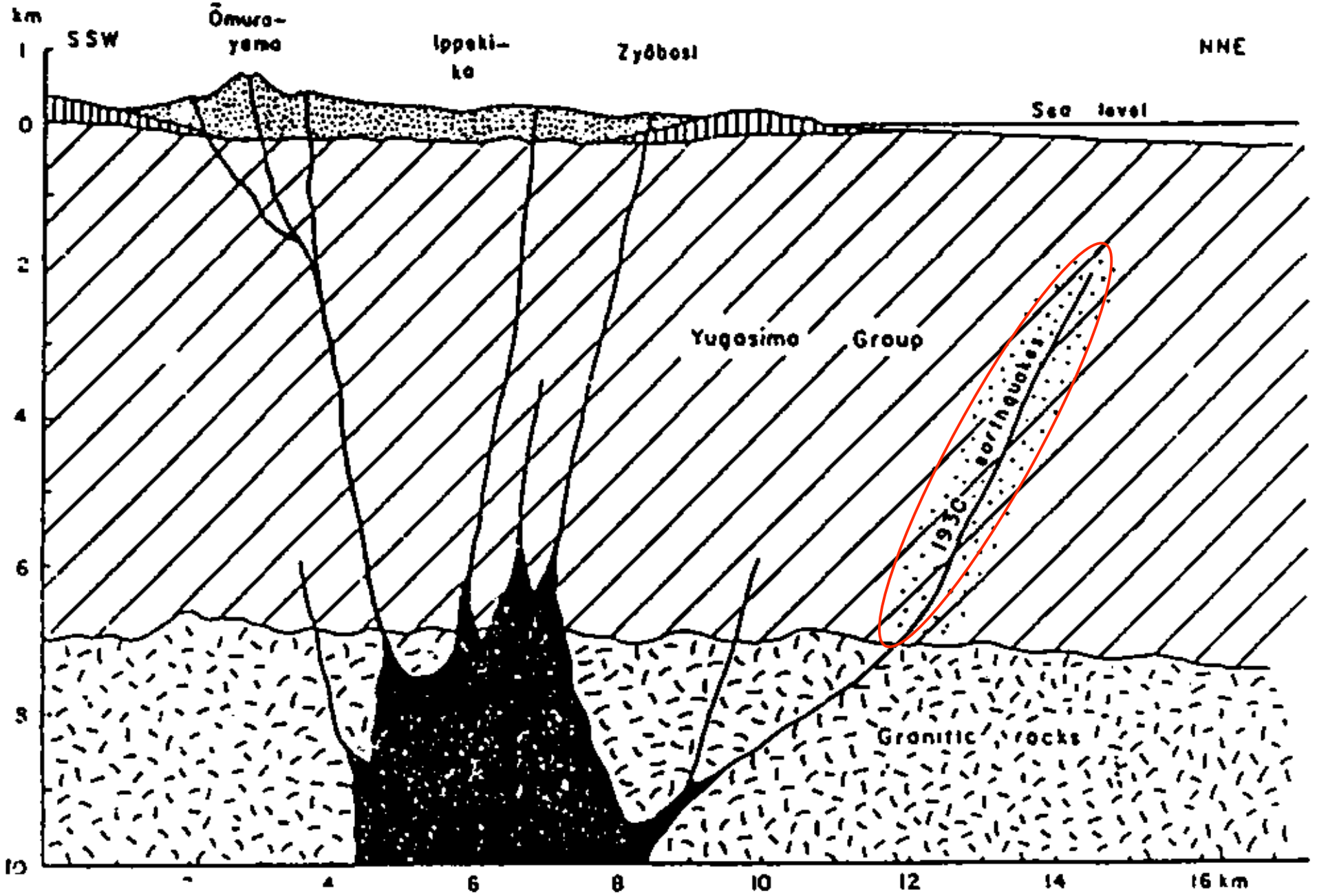
Dyke intrusion model for 1989 seismo-volcanic activity

Period	Tensile				Shear
	F1	F2A	F2B	F2C	F3
1989年 5/21－25	25cm	—	—	—	—
7/1 －7/4 08h	—	25cm	—	—	—
7/4 08h－7/5 11h	—	40cm	40cm	40cm	—
7/5 11h－7/8 20h	—	40cm	40cm	40cm	—
7/8 20h－7/11 03h	—	40cm	40cm	10cm	—
7/9 11h09m	—	—	—	—	30cm

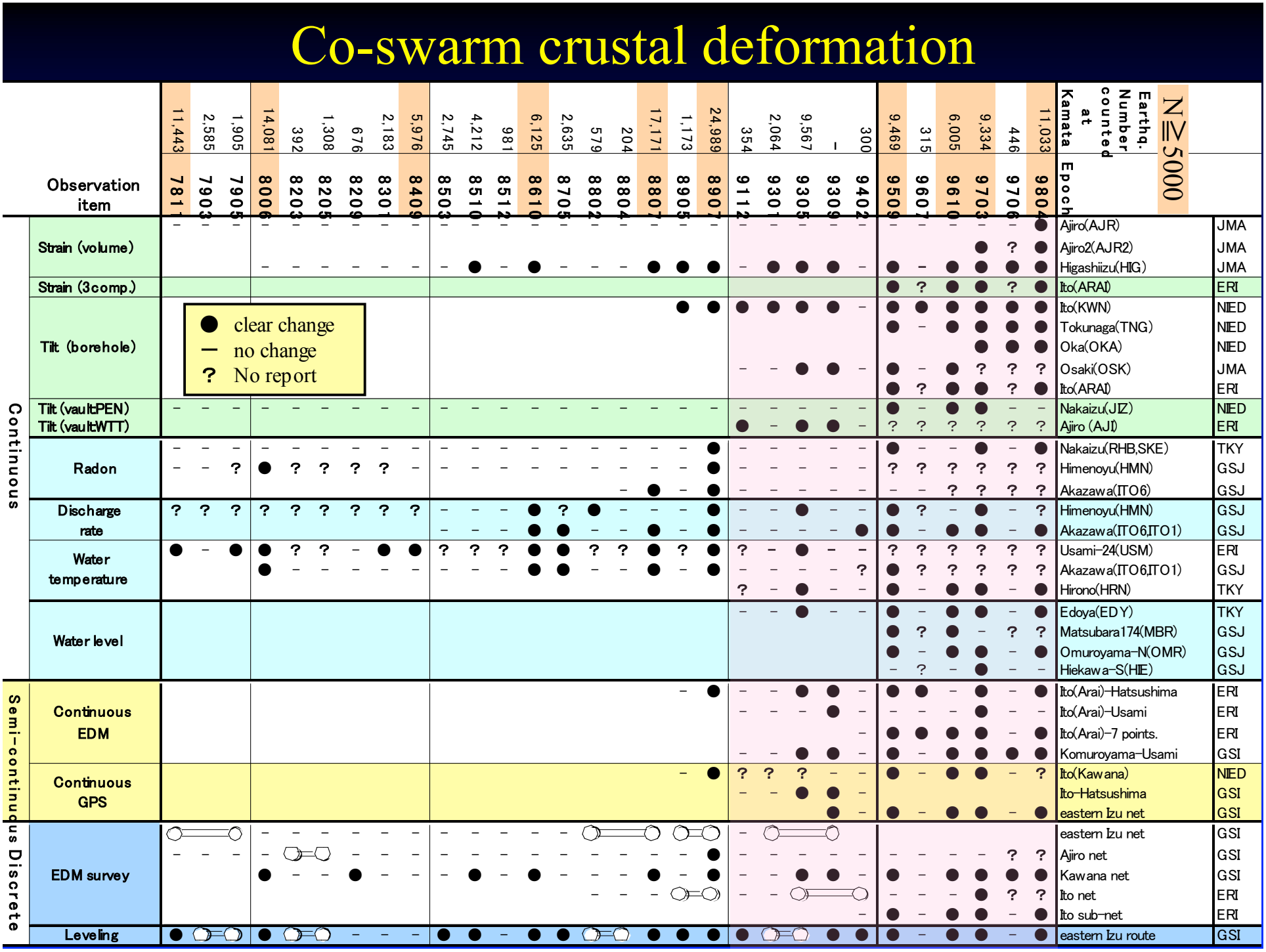


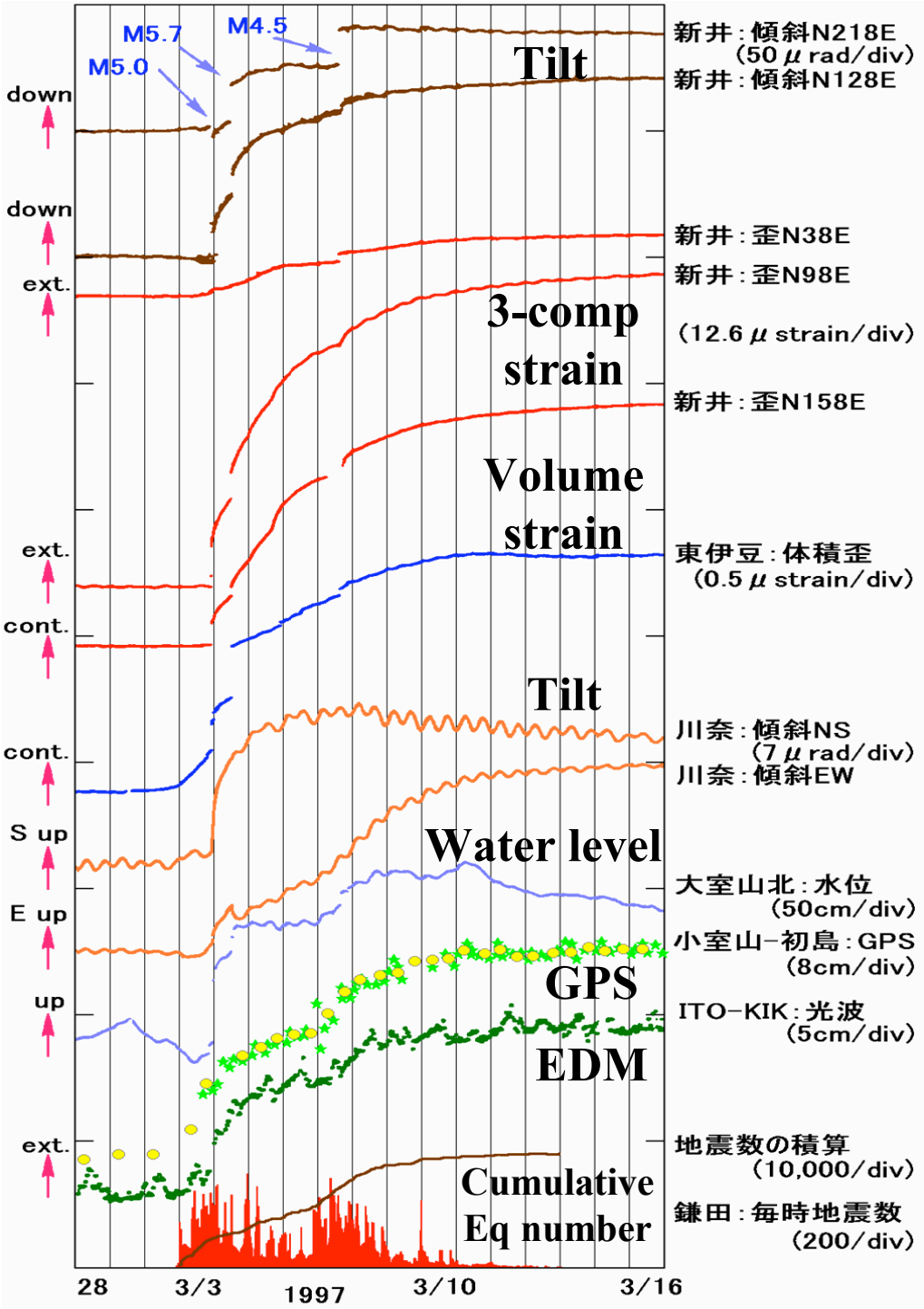
(Okada & Yamamoto, 1991b)

Swarm in 1930 and its magma source (Kuno,1954)



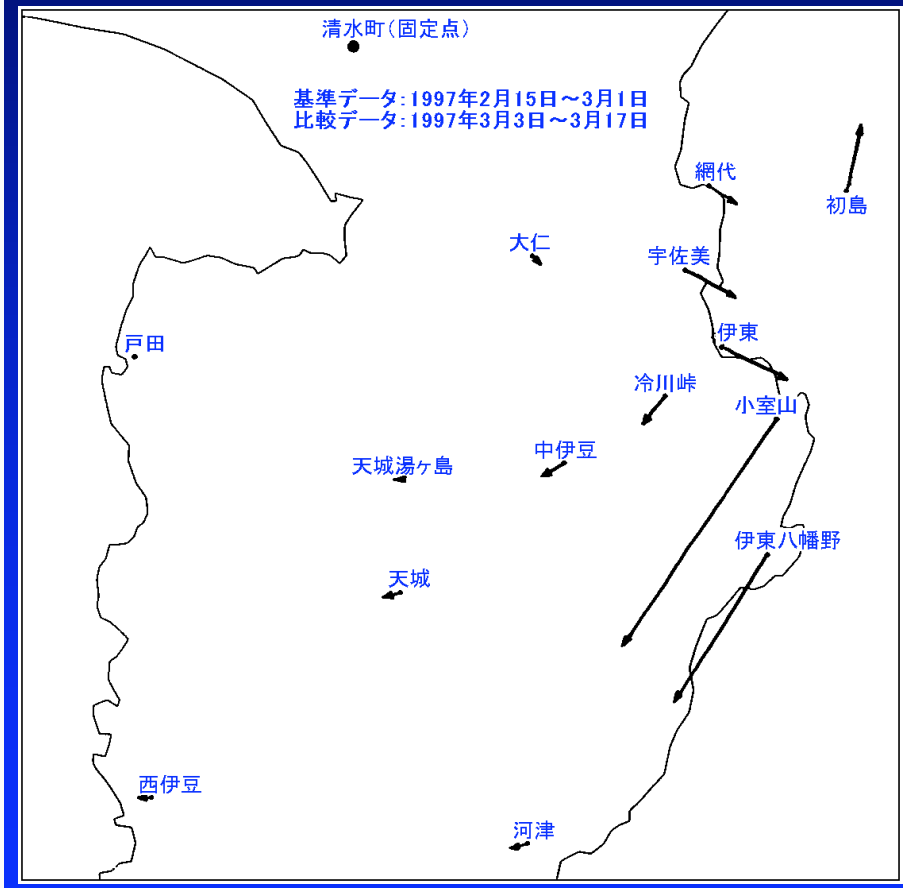
Co-swarm crustal deformation





A major swarm in March 1997

GPS observation (GSI)



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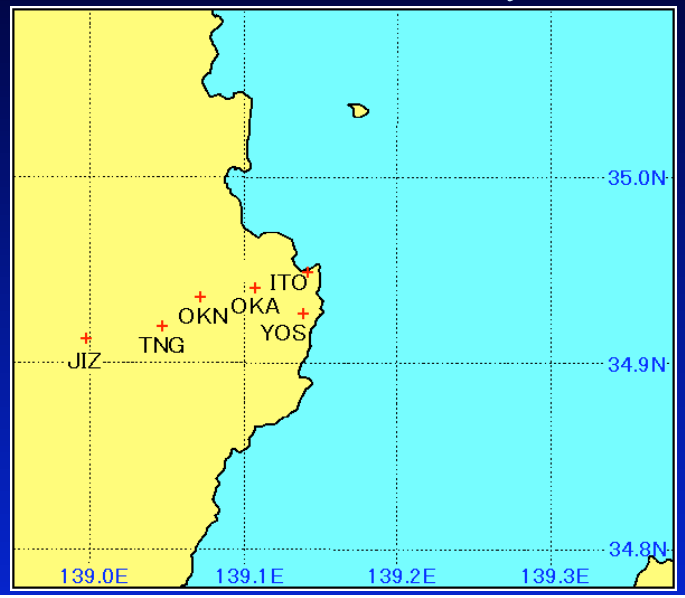
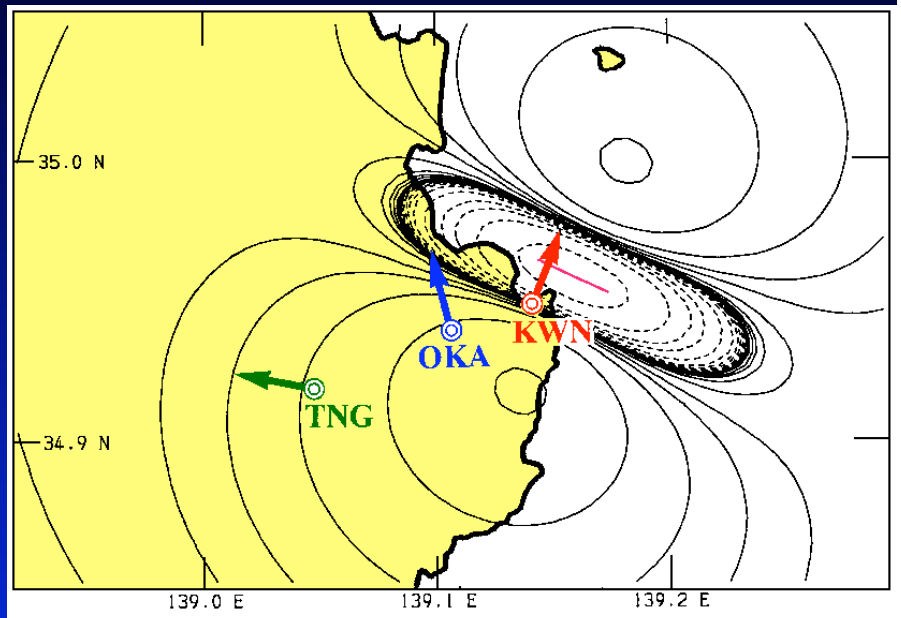
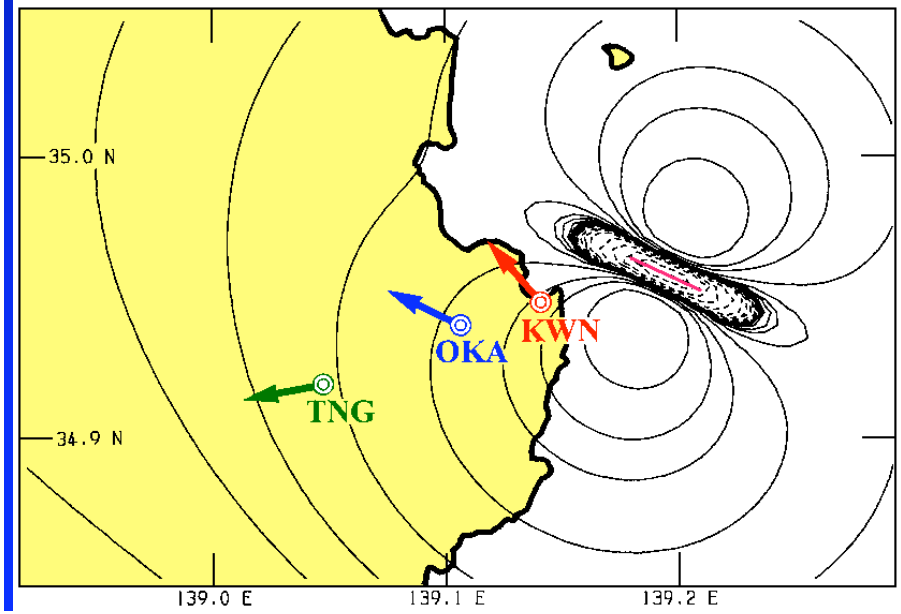
Co-swarm tilt associated to a swarm in April 1998

Tiltmeter array



Dyke intrusion model





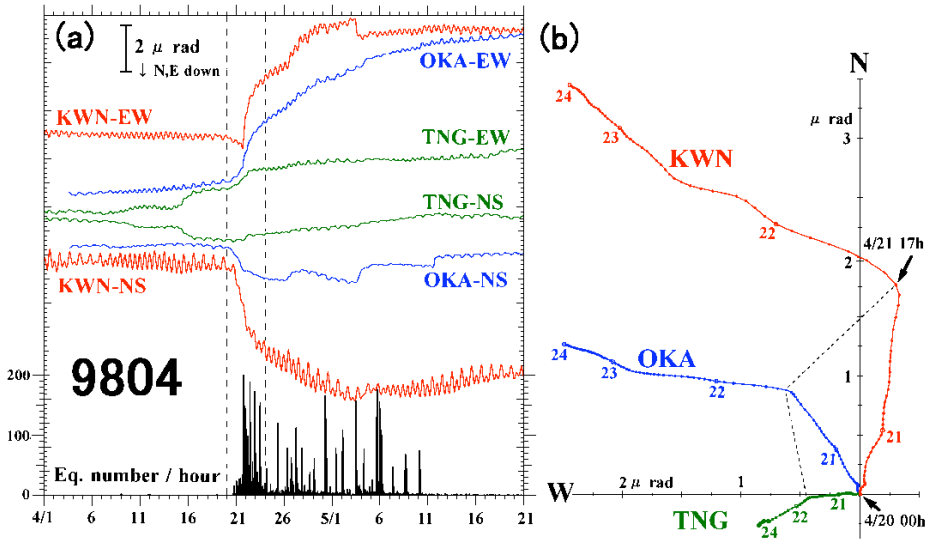
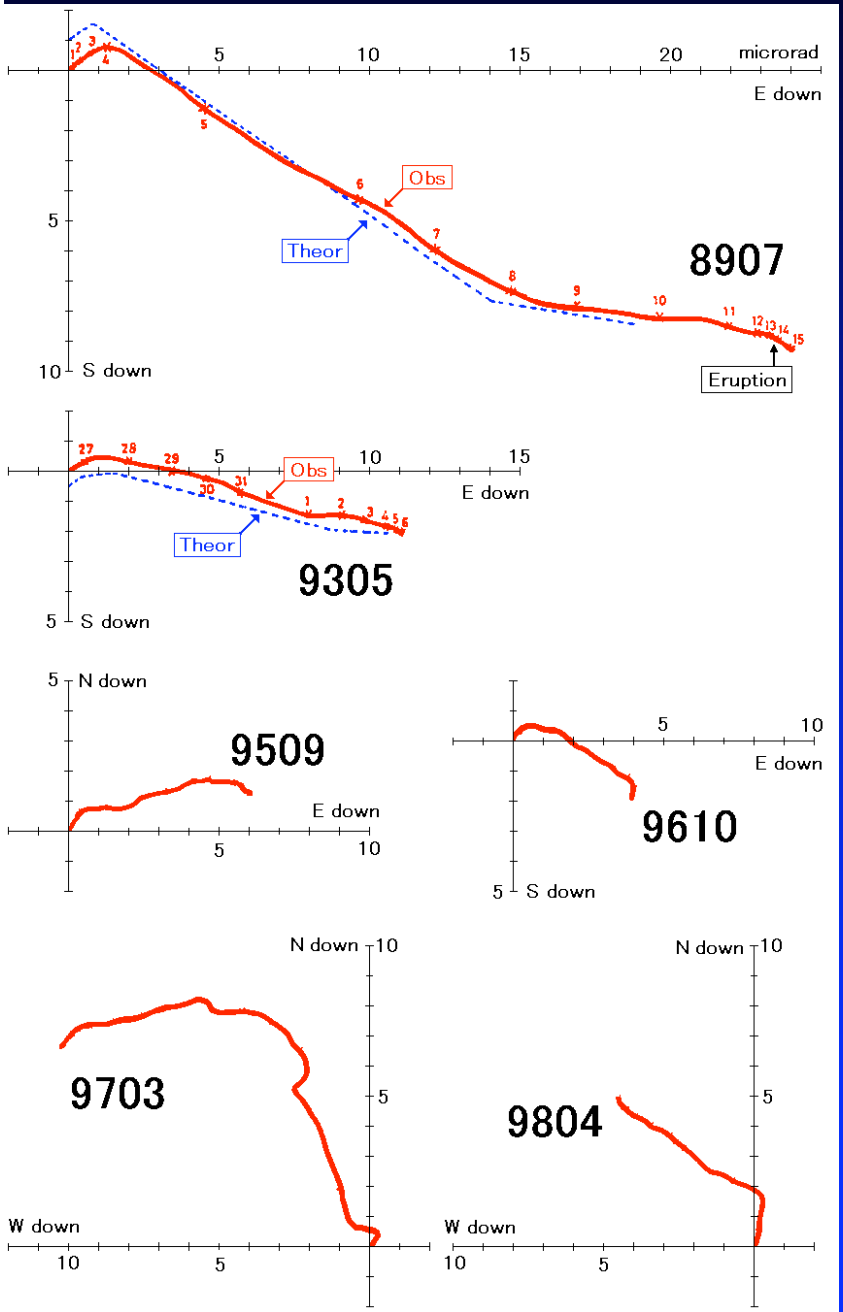
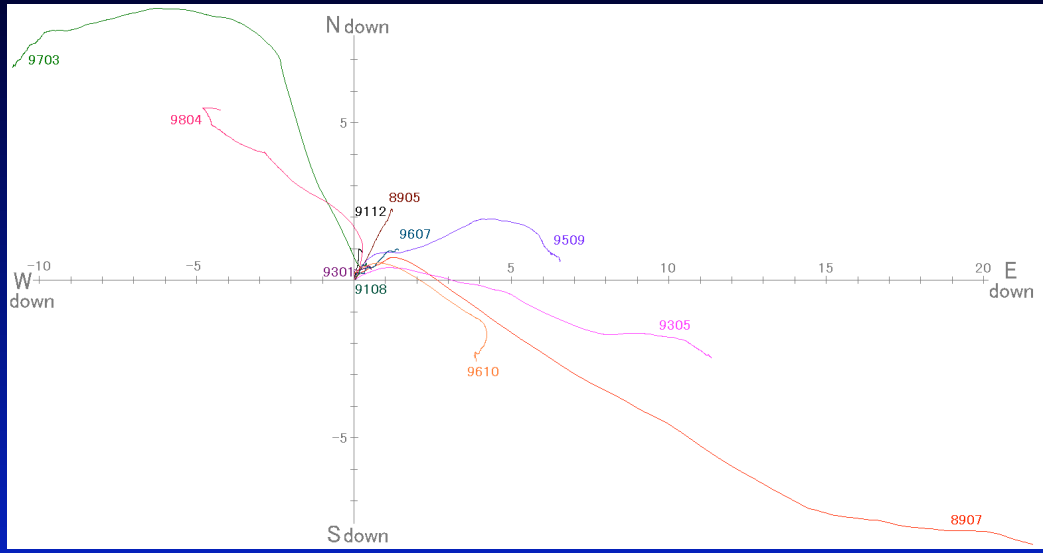


Figure 6. (a) Tiltmeter records at KWN, OKA, and TNG for the period April 1 to May 21, 1998, compared with the hourly numbers of the located earthquake. All coseismic steps are eliminated. (b) Tide-removed tilt-down vector diagrams at the three stations within 4 days, April 20–23, which corresponds to the period between the dashed lines in Figure 6a.

Tilt down vector change at KWN station





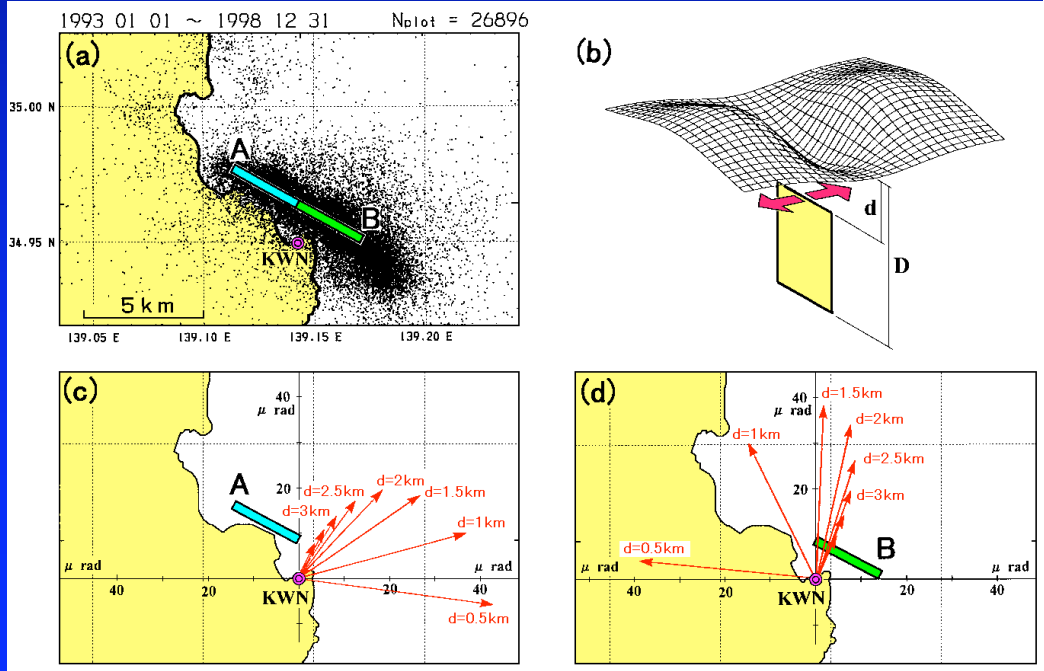
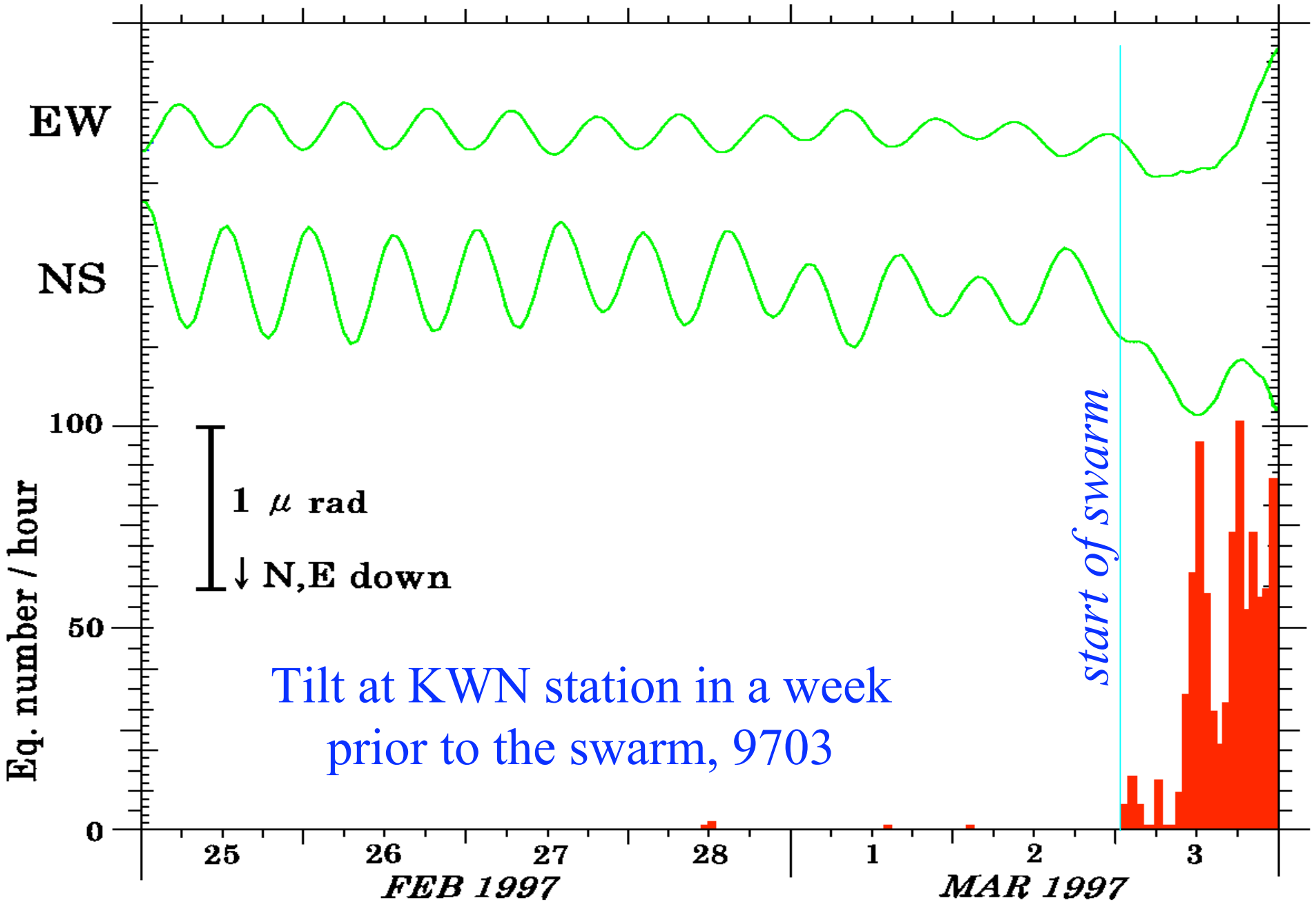


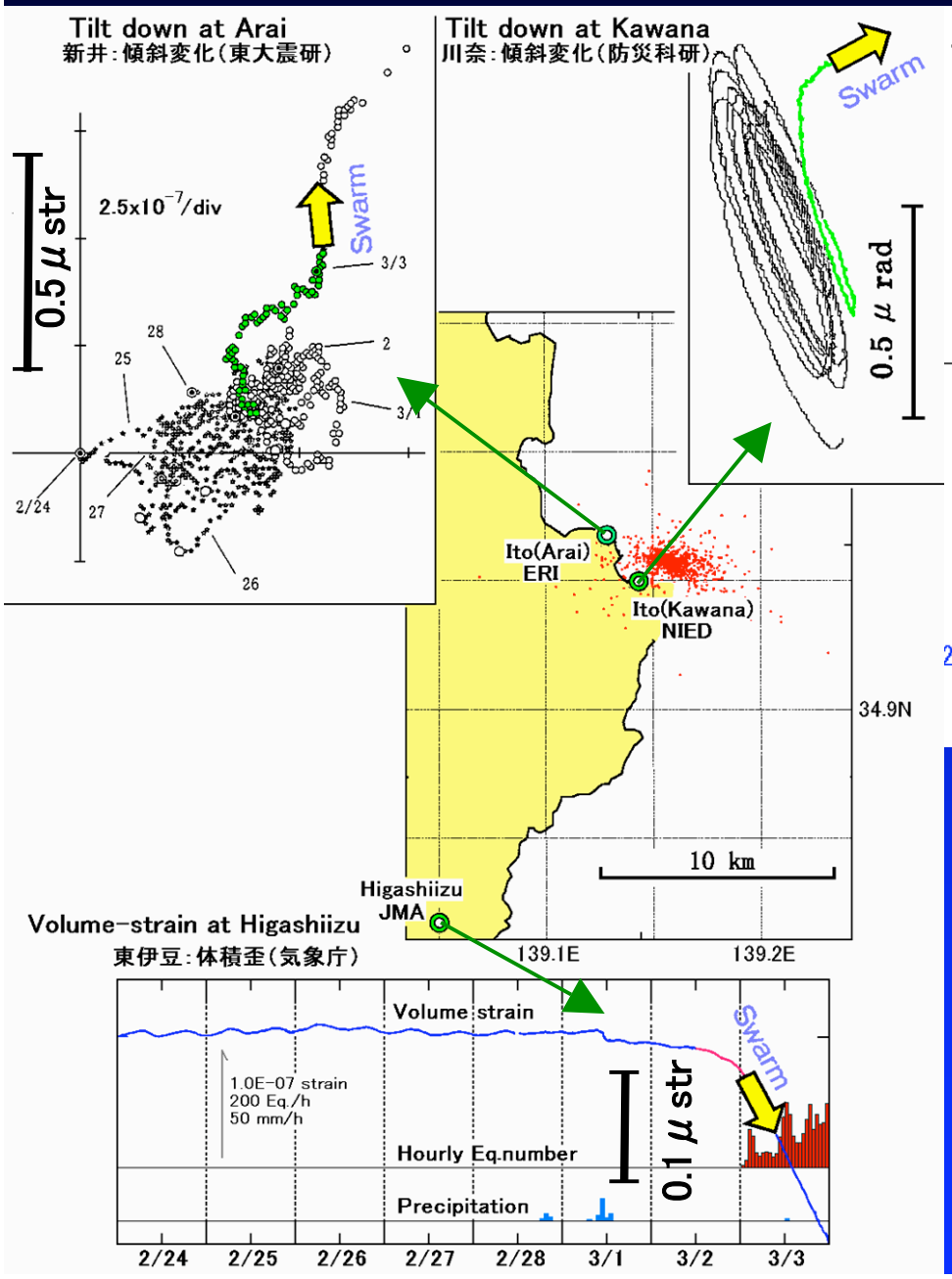
Figure 5. (a) Two vertical tensile fault models, A and B, along the swarm zone. (b) Schematic surface elevation change due to a buried tensile fault, whose top and bottom depths are d and D, respectively. (c) Expected tilt-down vectors at KWN for model A. (d) Expected tilt-down vectors at KWN for model B.

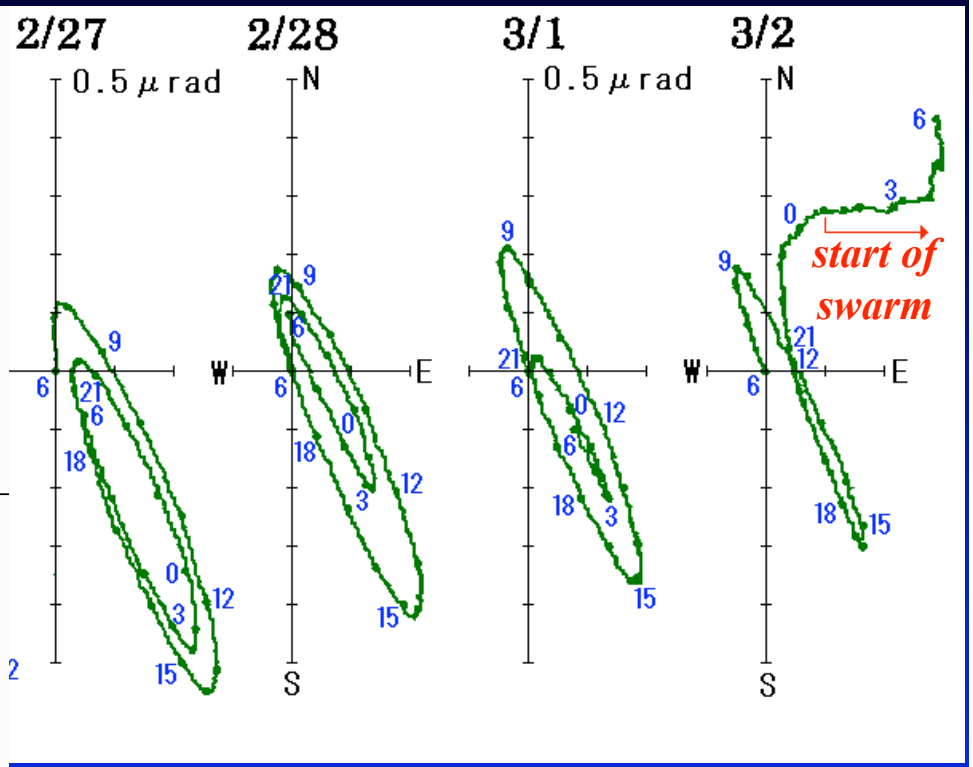
Pre-swarm crustal deformation

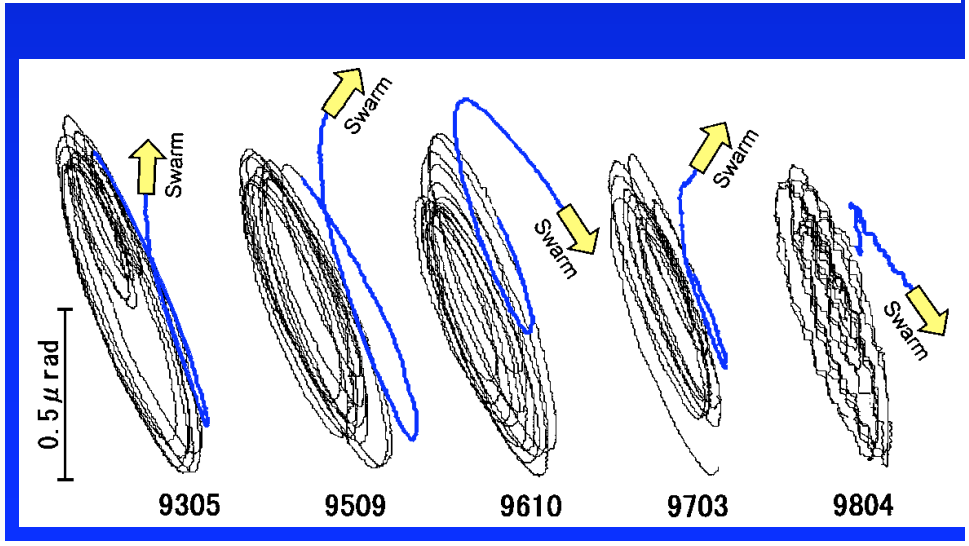


Tilt at KWN station in a week prior to the swarm, 9703

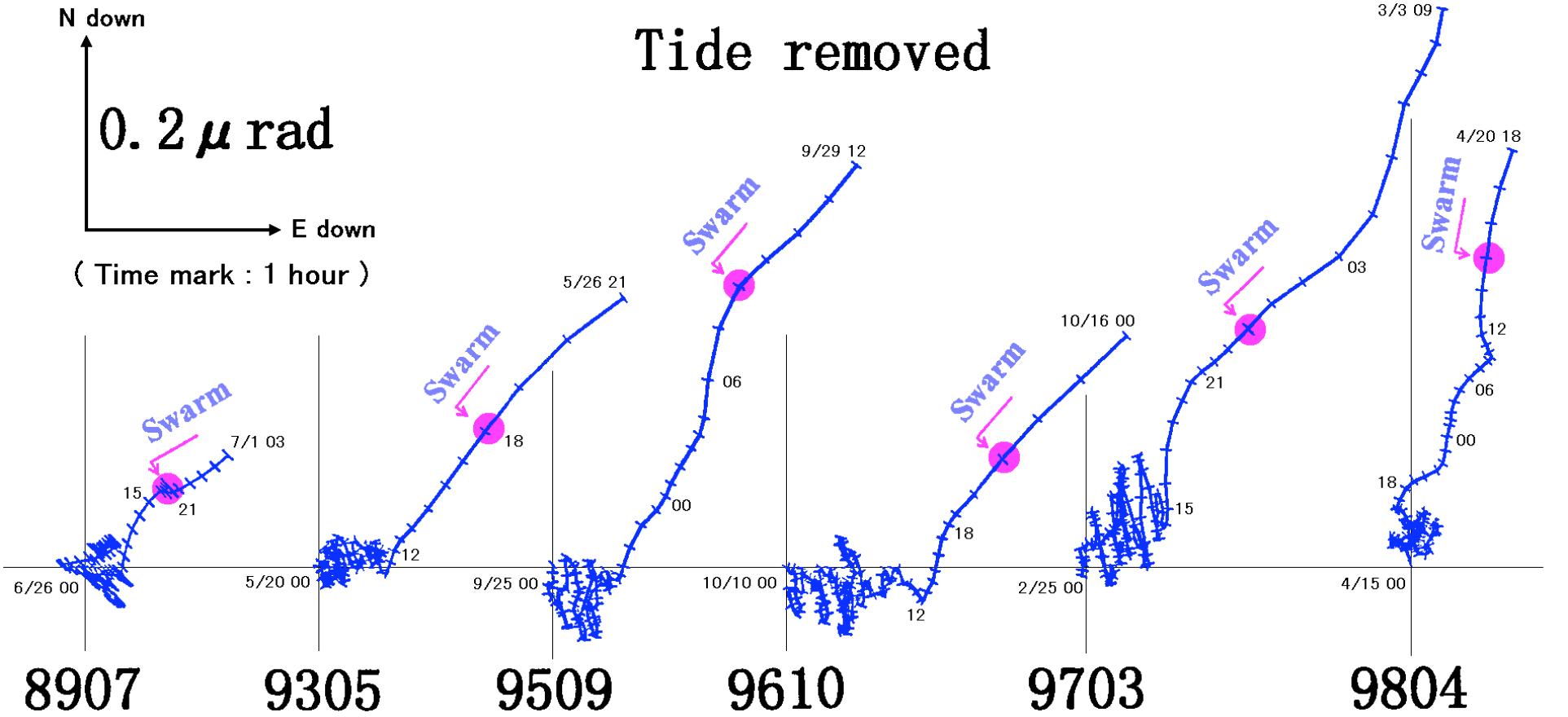
Daily tilt vector change at KWN



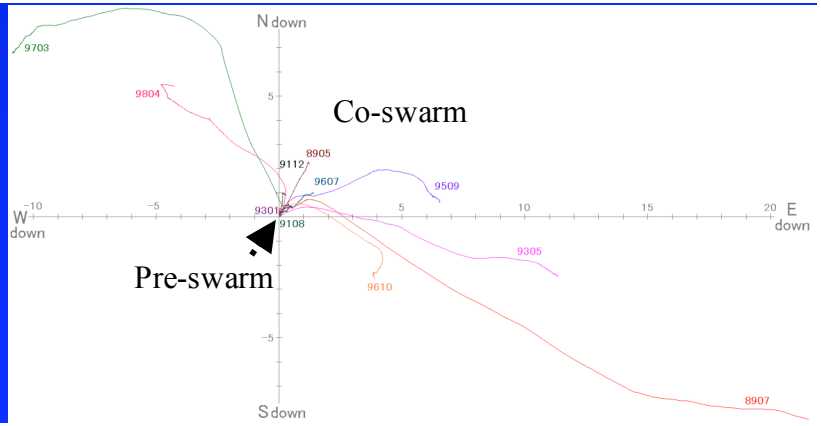




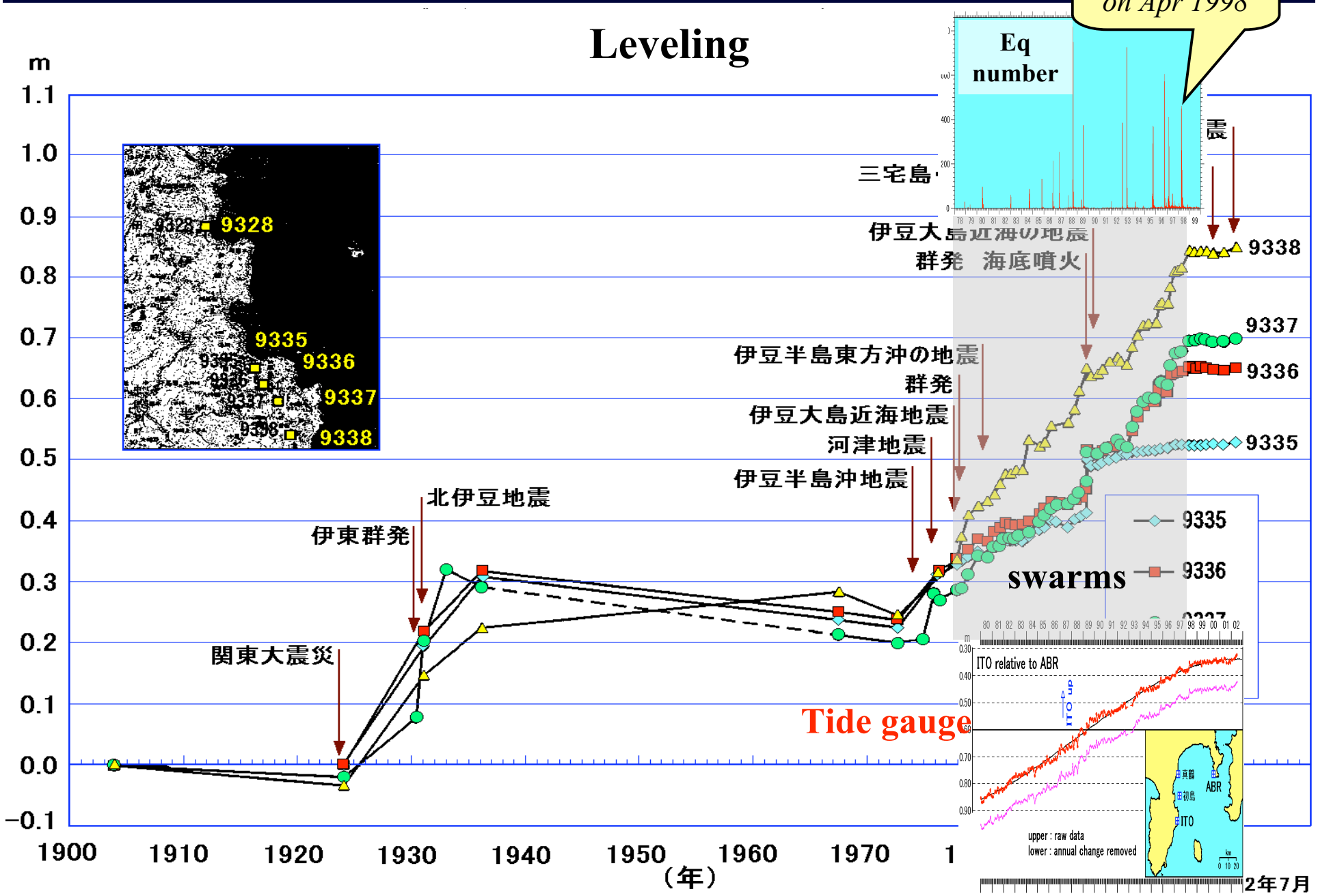
Pre-swarm tilt vector change (tide removed)



1) Clear only for major swarms
2) Precede several hour to half a day
3) Signal level is order of 0.1μrad
4) Always NE down and smoothly connect to co-swarm change ⇒ **deep intrusion**

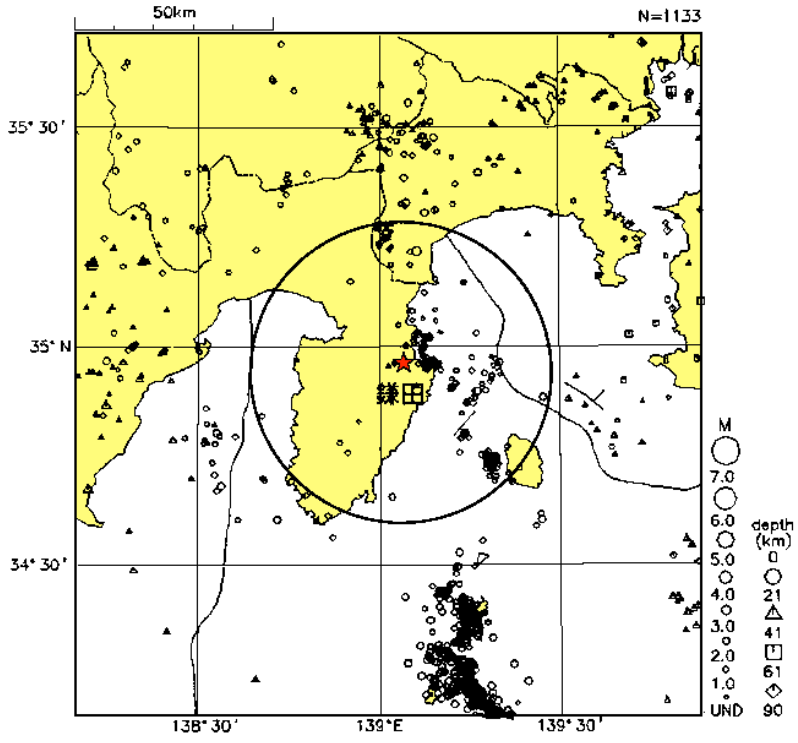


Did crustal deformation stop ? (leveli



Recurrence of earthquake swarm

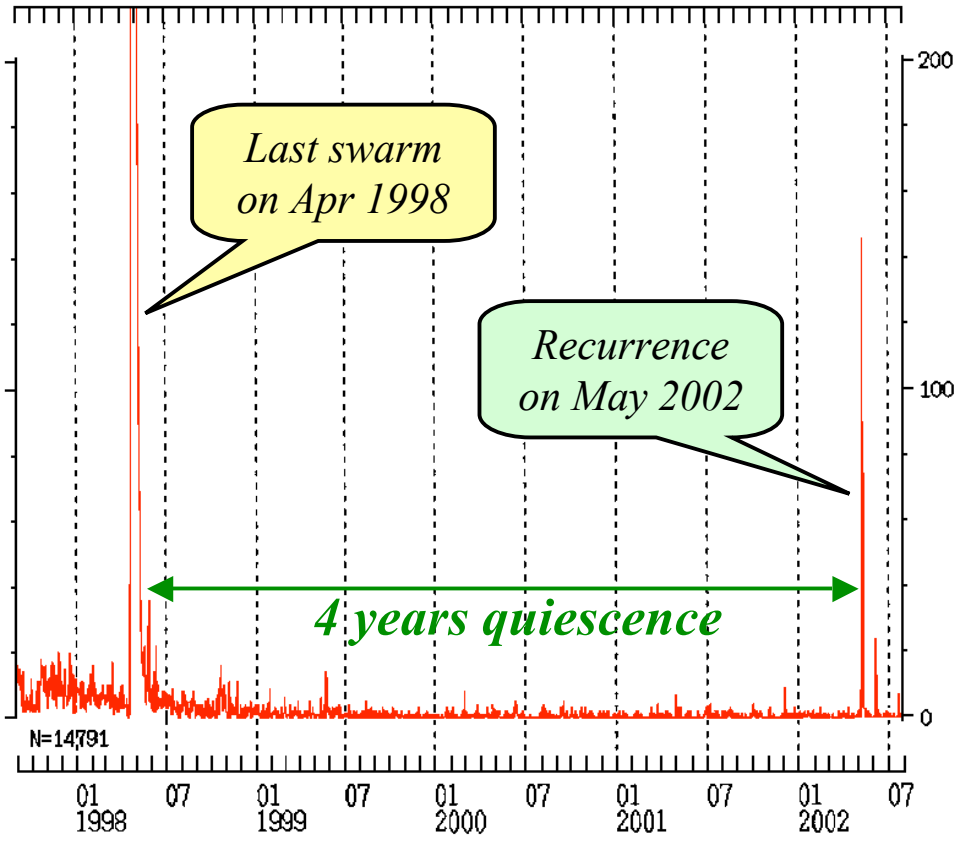
Epicentral distribution during 5/1 – 7/31, 2002



0 ≦ 深さ ≦ 90 km
図の円内は鎌田における S－P≦6sec の範囲を示す。

Daily Eq number at KMT station

1997 年 9 月 1 日～2002 年 7 月 31 日（S－P≦6sec）

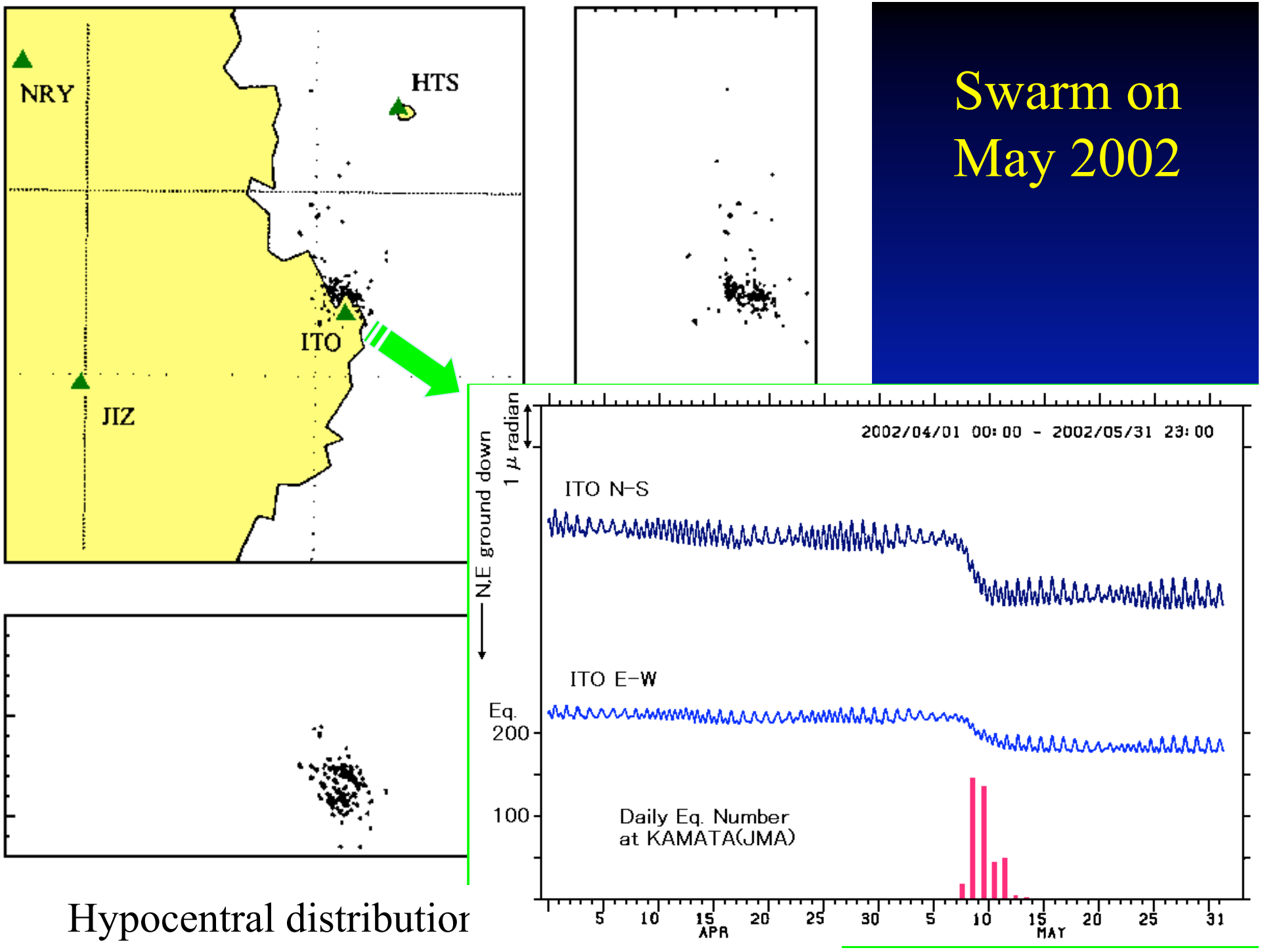


本年 5 月 8 日から 15 日にかけての伊豆半島東方沖の活動以降、静かな状態に戻っている。

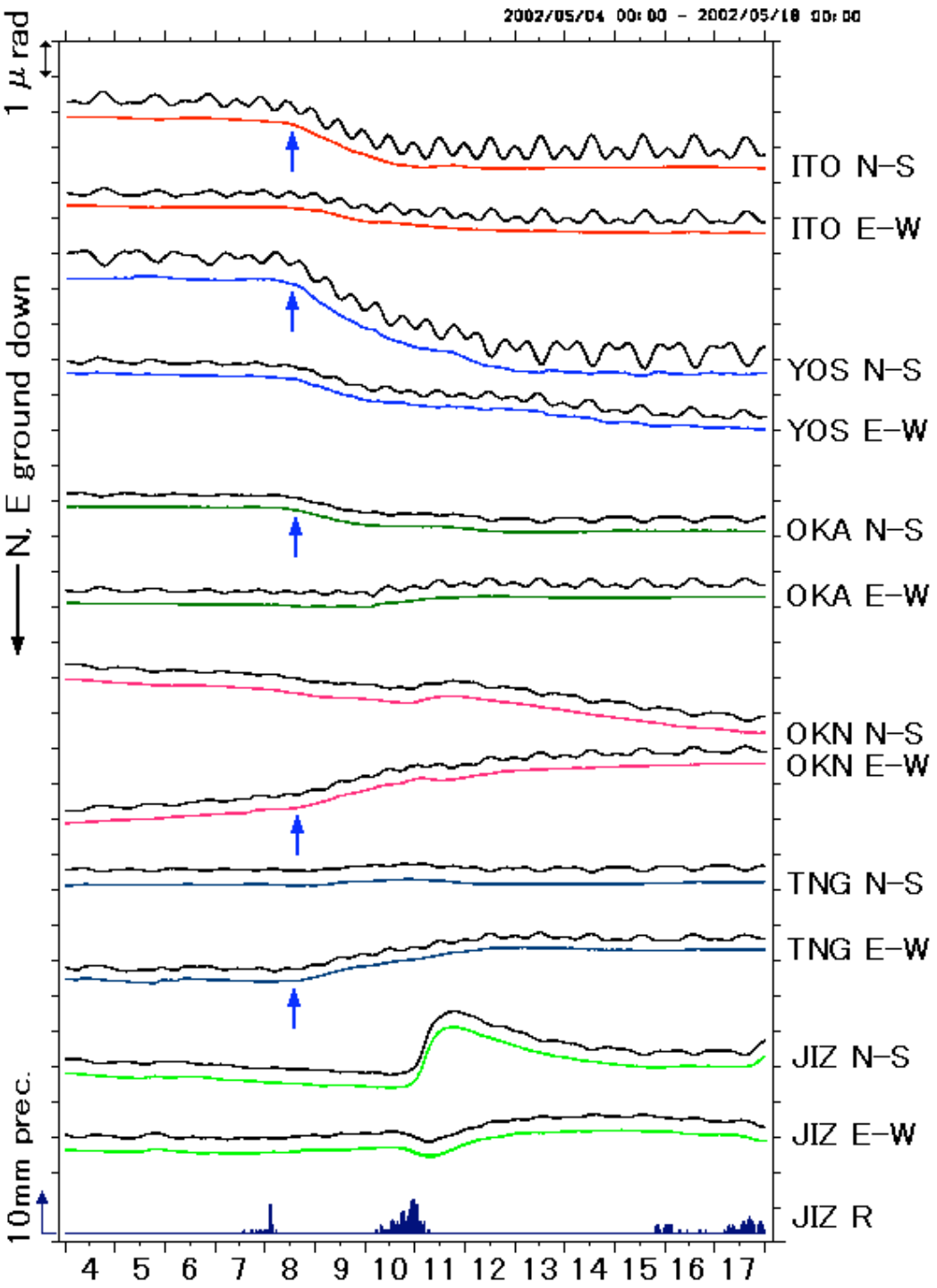
［暫定］　（気象庁，東京大学，名古屋大学および防災科学技術研究所のデータを使用）

気象庁作成

Swarm on May 2002

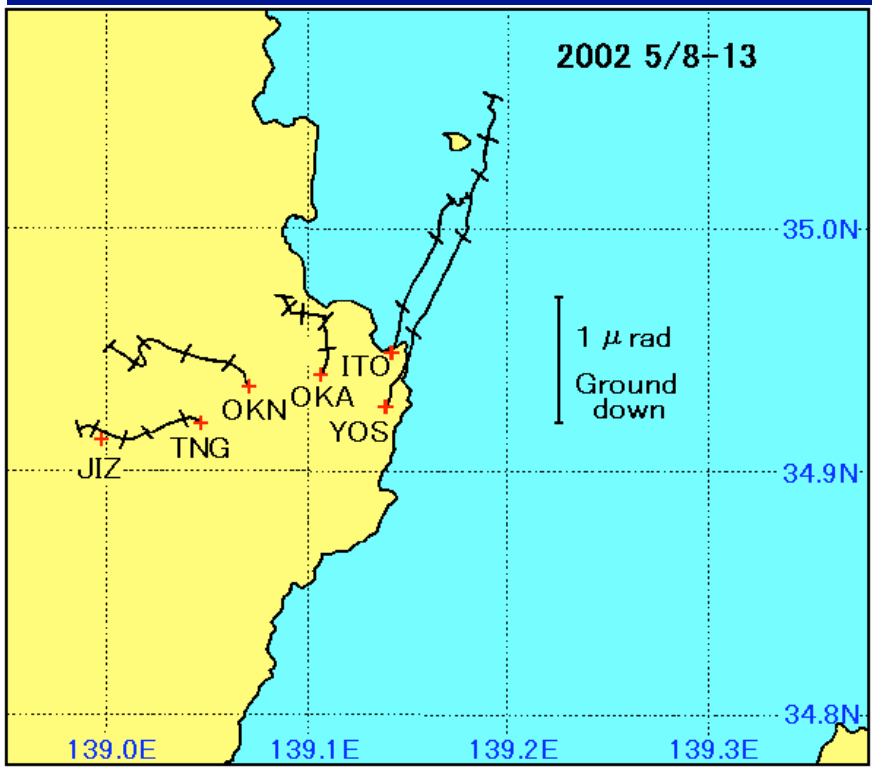


Hypocentral distributior



Tilt changes associated to the swarm 0205

Tilt vector change



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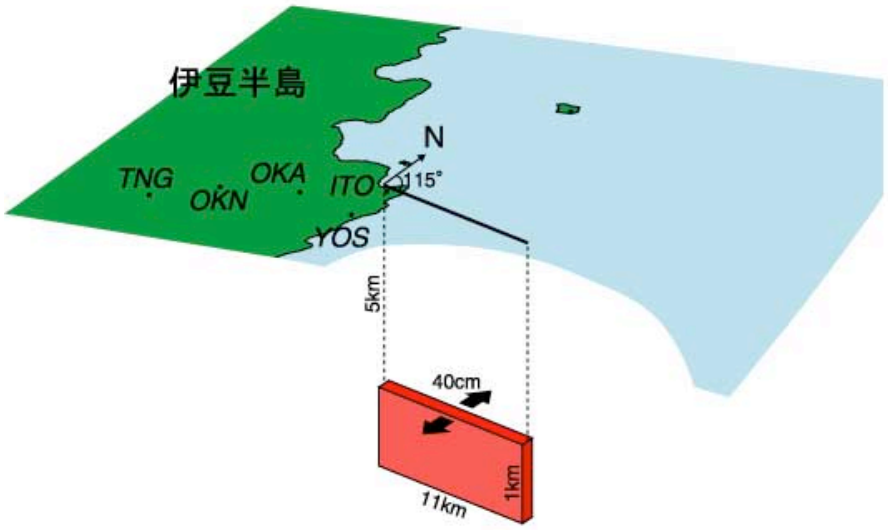
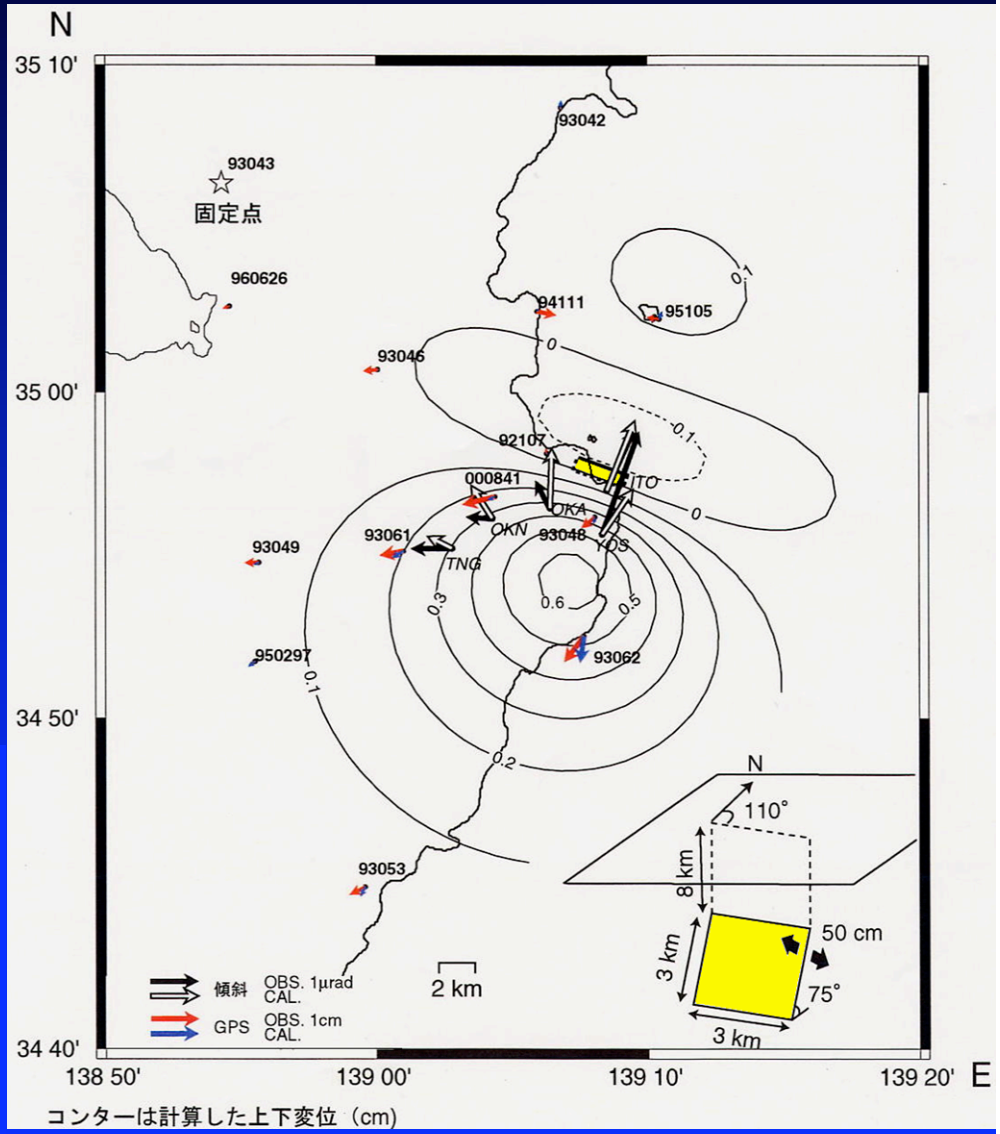
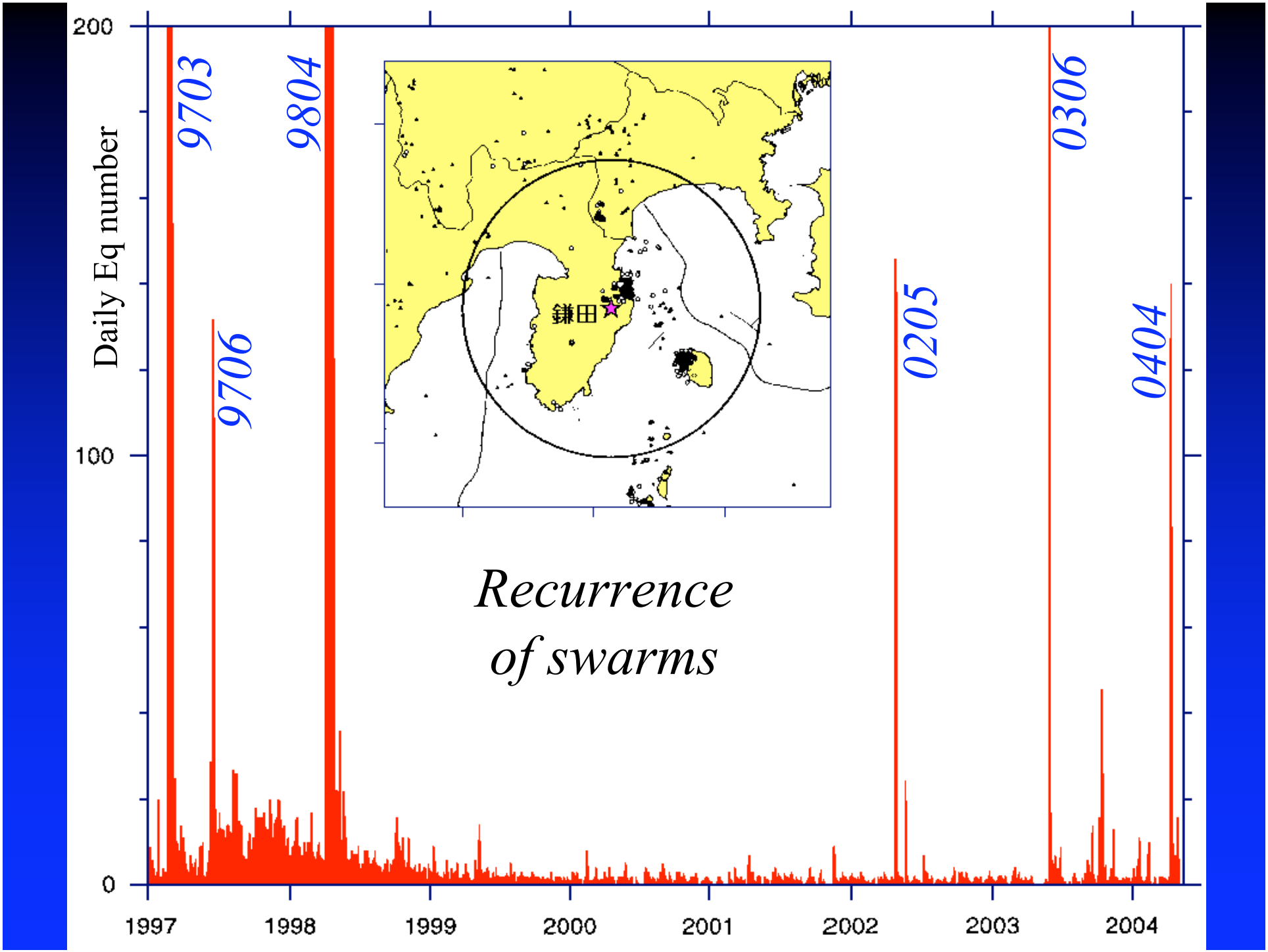
Dyke intrusion model for the swarm 0205

1st approximation model using tilt data

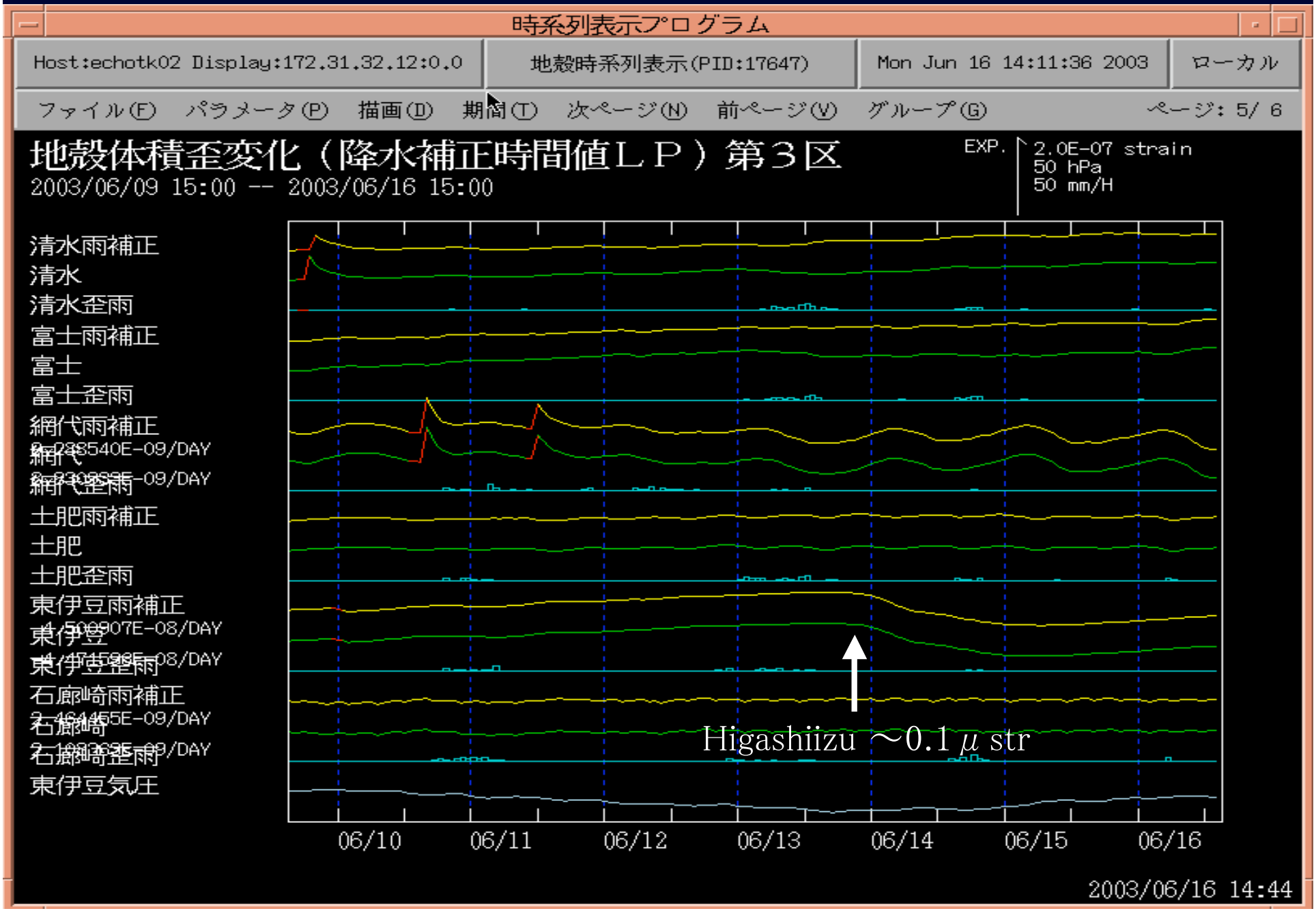


2nd approximation model using tilt and GPS data

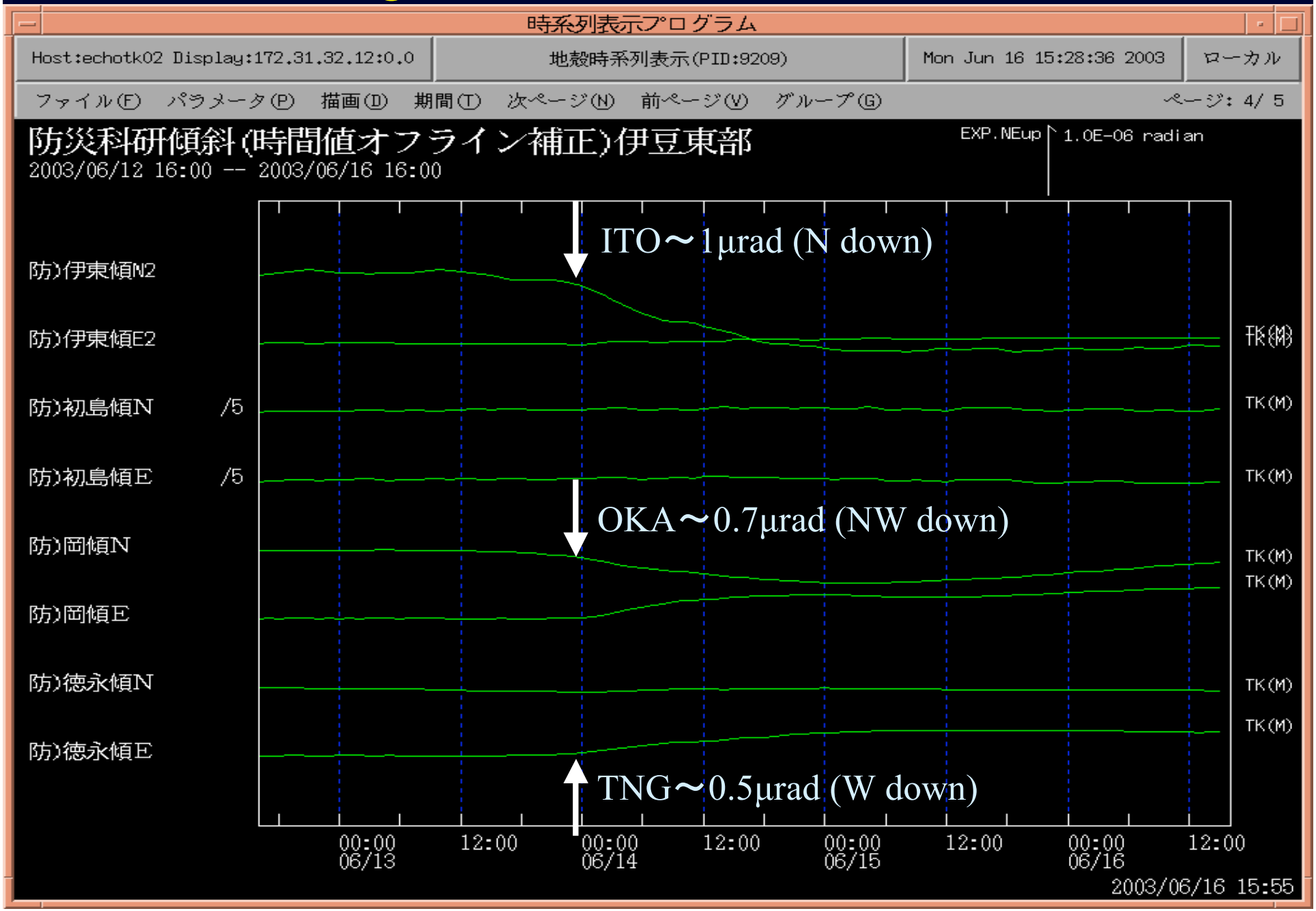



200
100
0
Daily Eq number
9703
9706
9804
0205
0306
0404
鎌田
1997
1998
1999
2000
2001
2002
2003
2004
Recurrence
of swarms

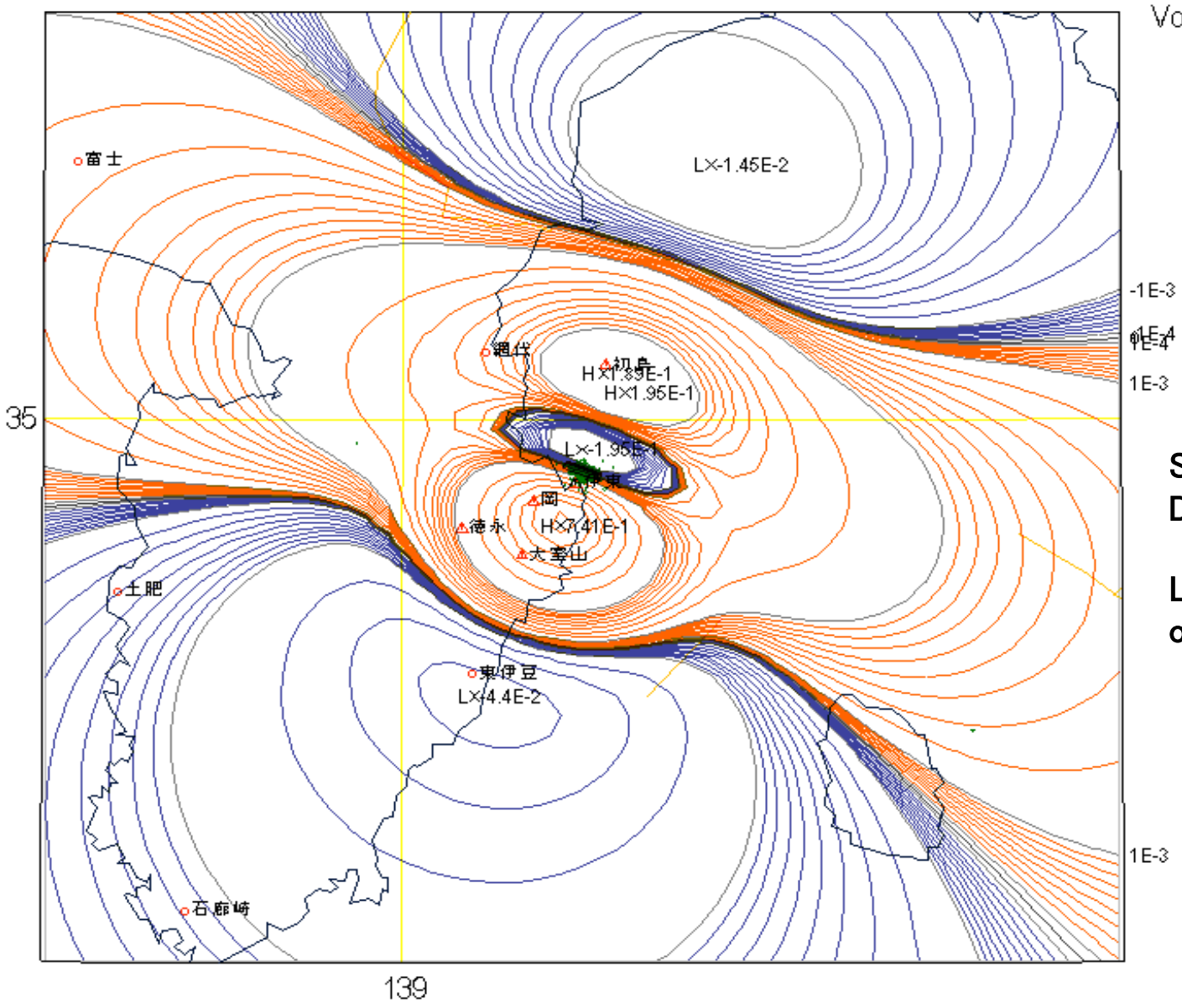
Volume strain associated to the swarm 0306



Tilt changes associated to the swarm 0306



Dyke intrusion model for the swarm 0306



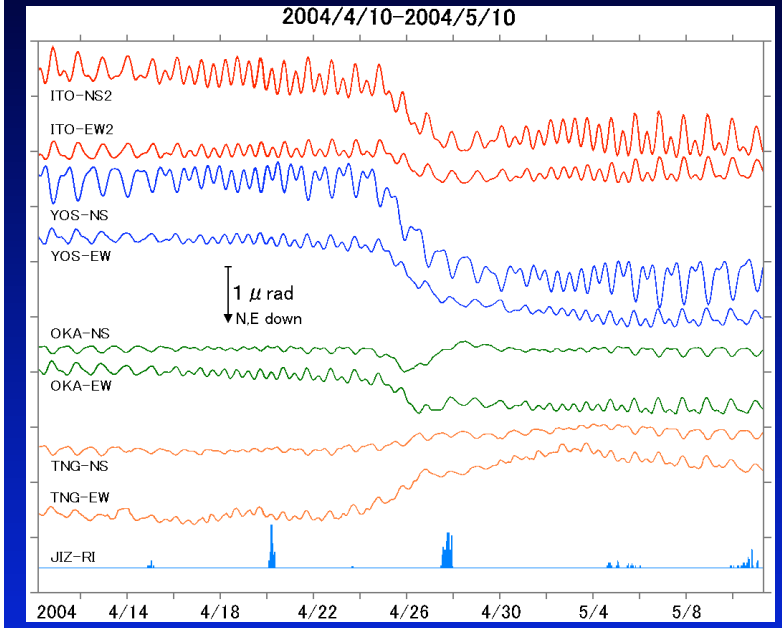
Strike: N110E
Dip : 75deg
(Those are same as 0205)
L = 3km, **W** = 2km
open = 50cm

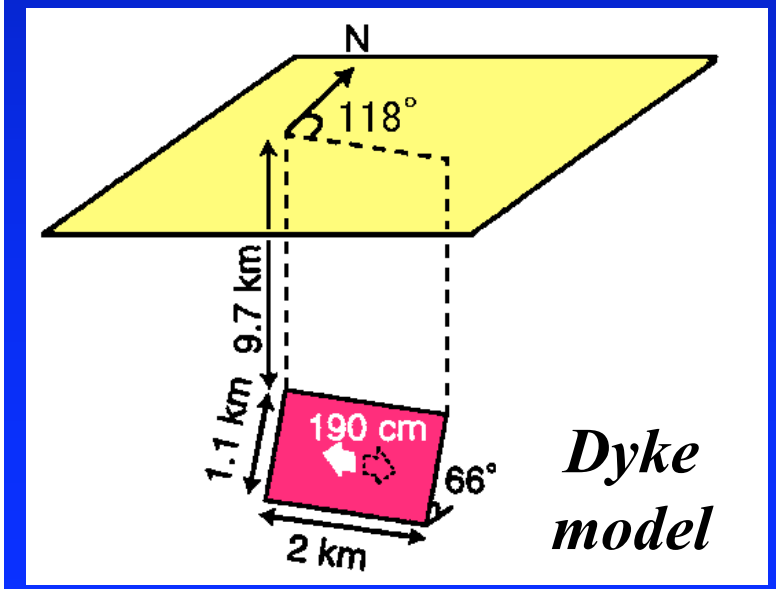
// MICAP-G //

(JMA)

Swarm on April 2004

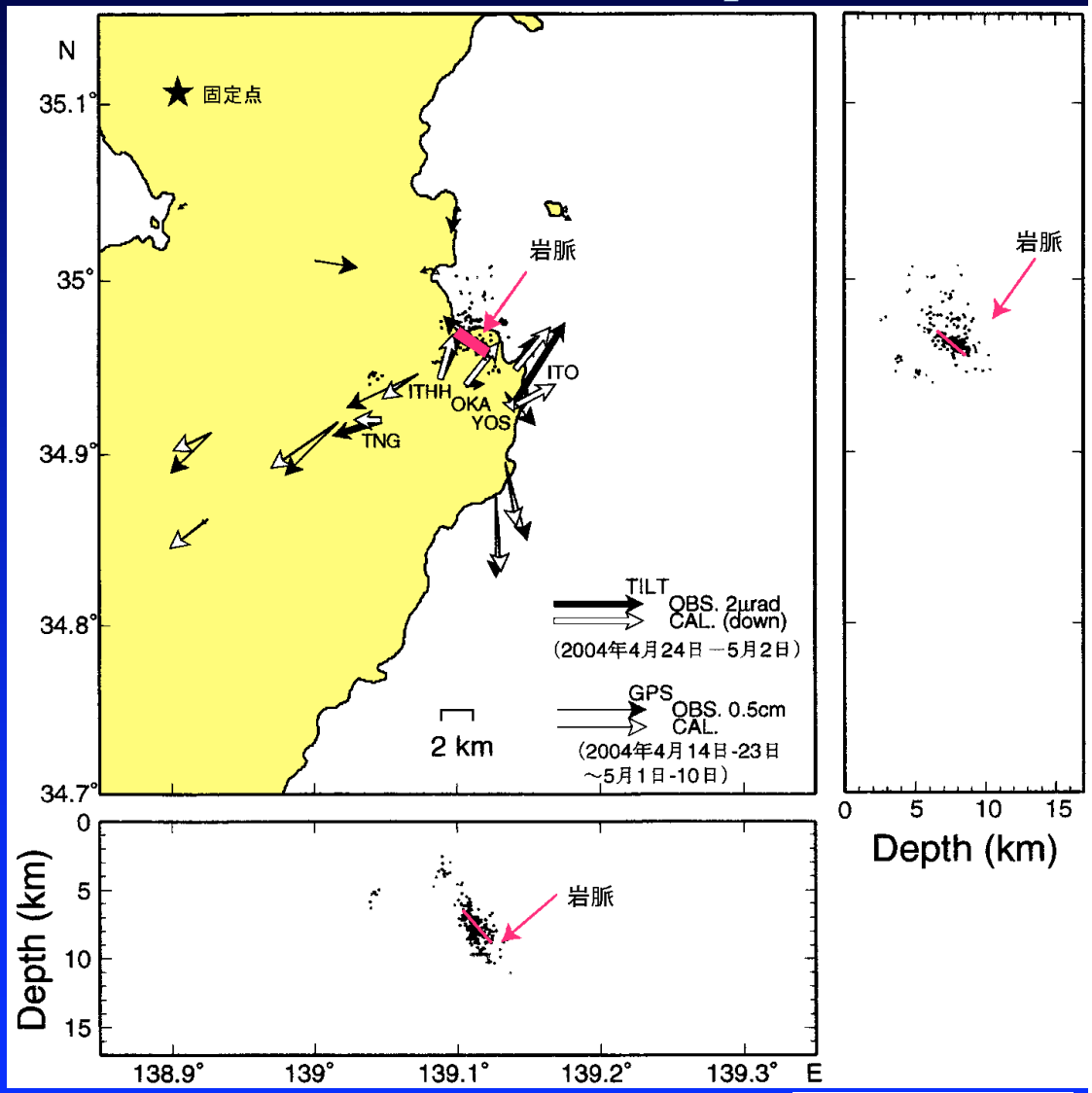
Tilt changes



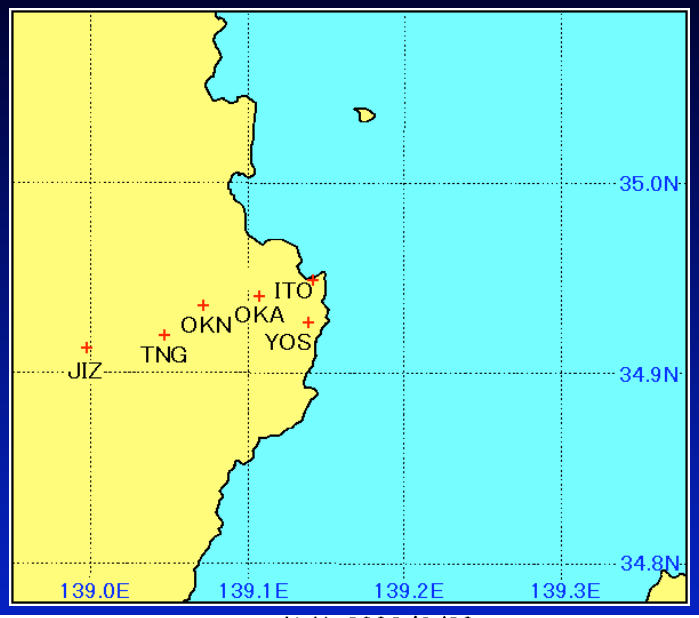


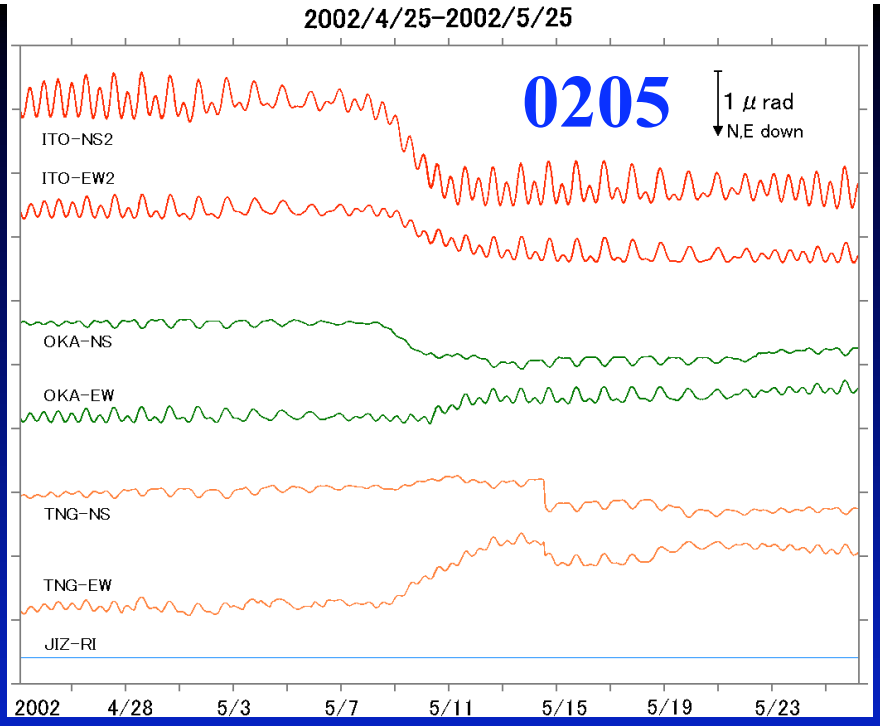
Dyke model

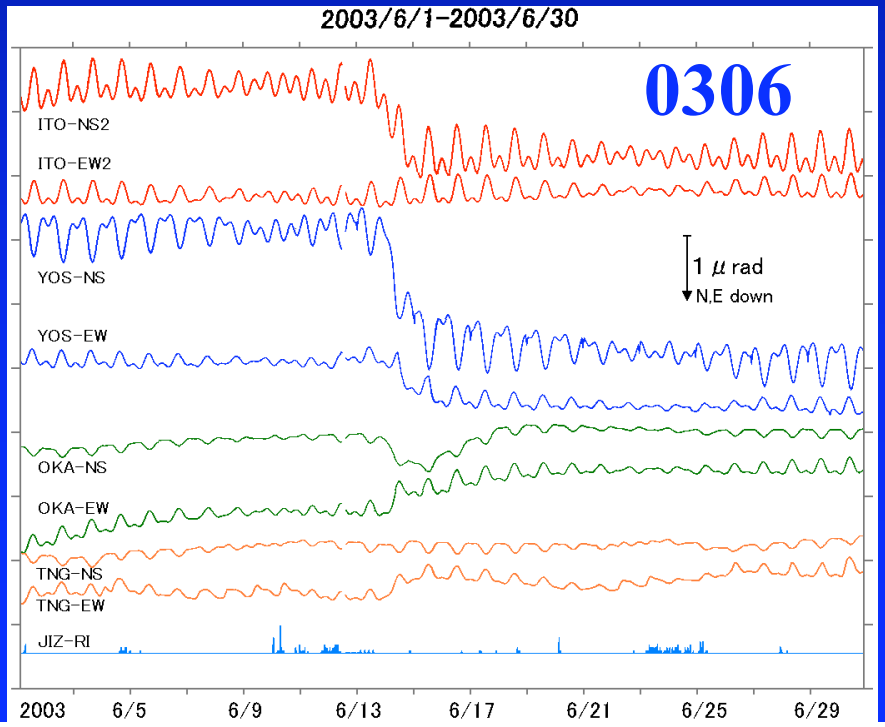
Tilt vectors and GPS displacements

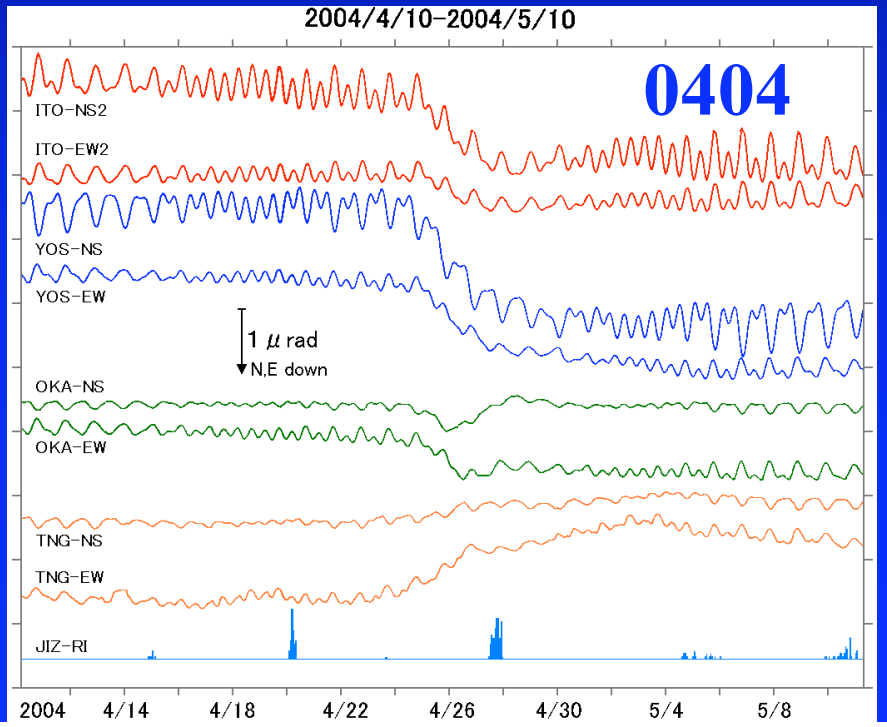


Tlit changes for recent swarms

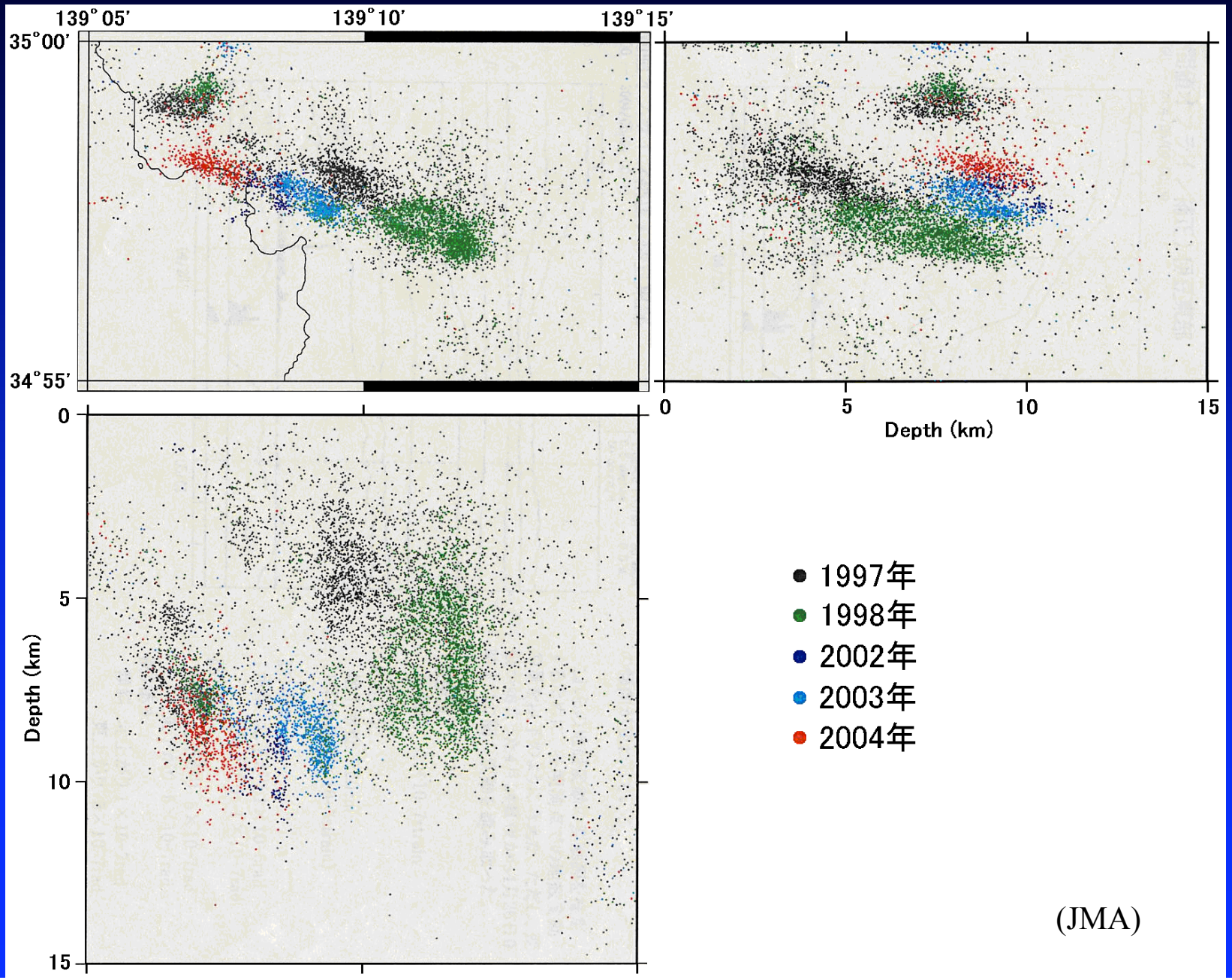








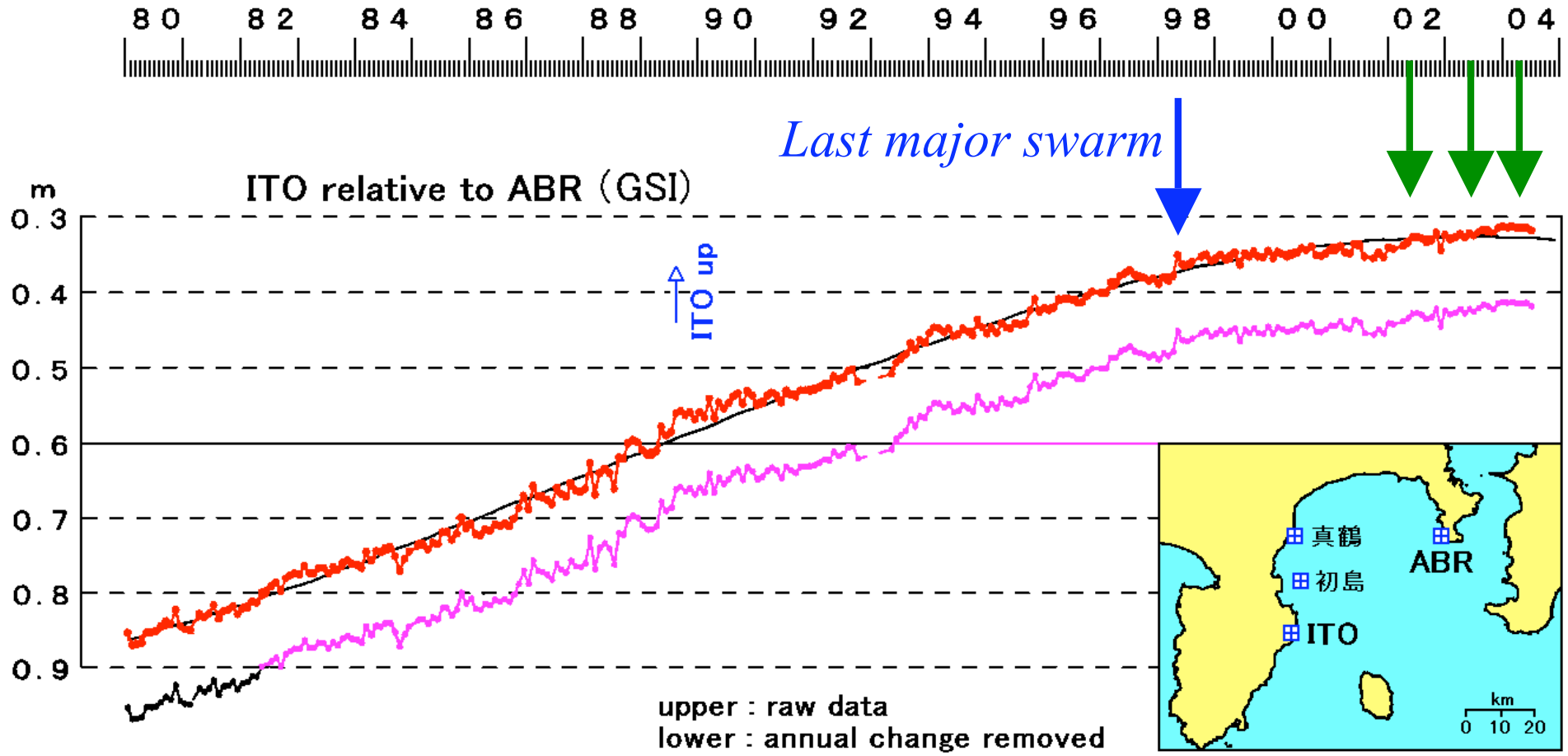
Hypocenters of recent swarms (relocated by DD method)



(JMA)

Did crustal deformation stop ? (tidal observation)

Recent swarms



Questions

(1) Until when the swarm activity will continue ?

(2) Will major swarm follow in near future ?

(3) Will volcanic event like in July 1989 recur ?

Technical challenge

How quickly can we issue an alarm preceding to the start of major swarm activity ?

NIED
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