The 2025 M7.7 Myanmar Earthquake and The Power Law of Earthquakes

Yoshio Okamoto

yossi.okamoto@gmail.com

http://yossi-okamoto.net/

Chiang Mai Univ. DS 4 th Dec.2025

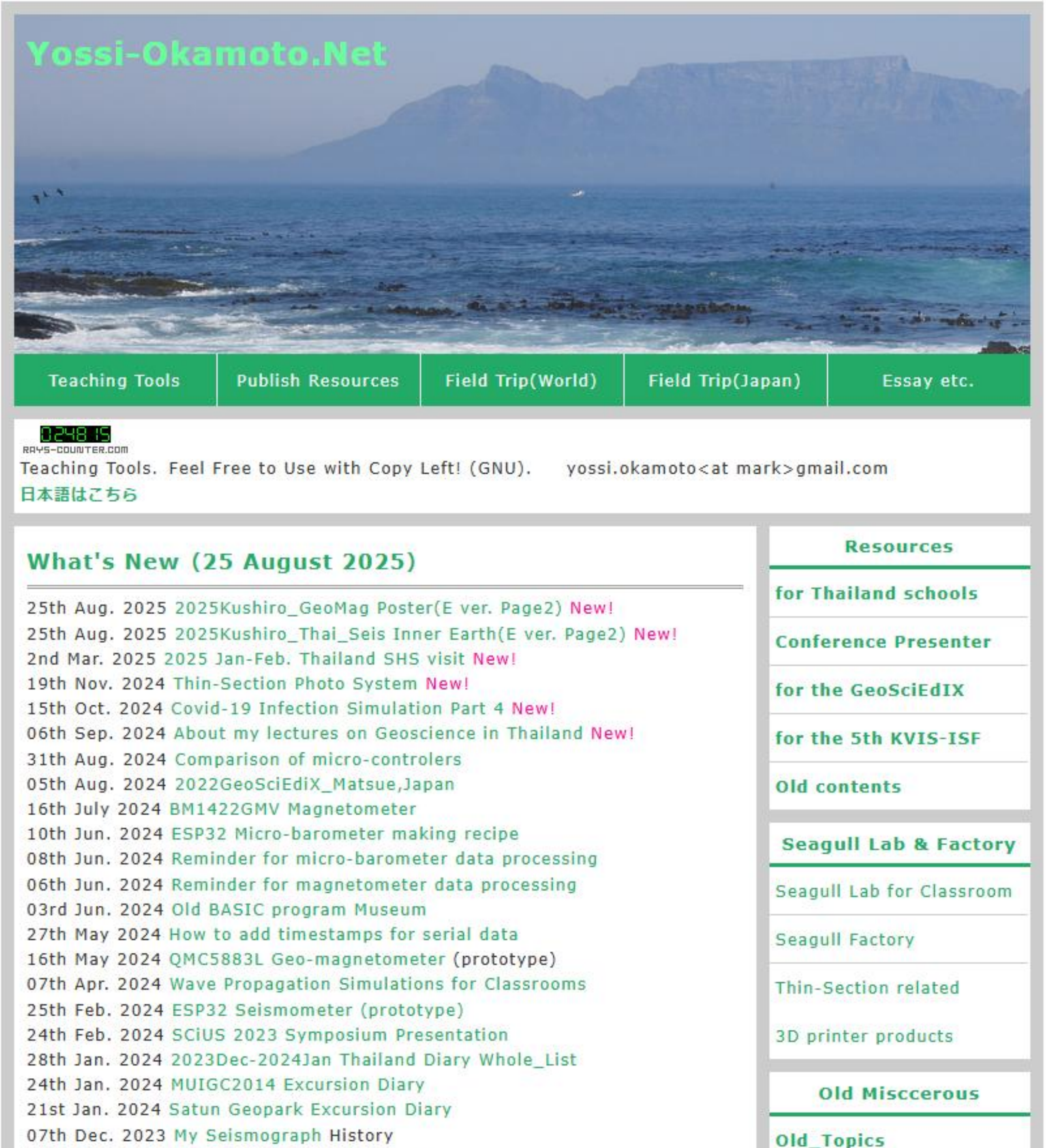
Today’s Overview

- About The 2025 M7.7 Myanmar Earthquake

- What is important in earthquake statistics?
 -> These boring statistics are actually closely related to whether earthquake prediction is possible or not.

Who ar

- **Earth Science** high-school teac
- Associate professor and part-ti
  Osaka-Kyoiku University 2(
- Geo Science class at **KVIS**, **PCSI**
  Chiang Mai Univ. DS, Phayao U
- School Seismograph System (at
  Loei, PCSHS NST, Chiang Mai U
  Univ.)
- 3D seismicity maps, tsunami si
- Polarized microscope unit & Th
- 3D printing (2019-) and all-rou
- Linux Programming (awk, C, Pr
  etc.). Now with the use of Clau



Yossi-Okamoto.Net

Teaching Tools | Publish Resources | Field Trip(World) | Field Trip(Japan) | Essay etc.

024815
RAYS-COUNTER.COM
Teaching Tools. Feel Free to Use with Copy Left! (GNU). yossi.okamoto<at mark>gmail.com
日本語はこちら

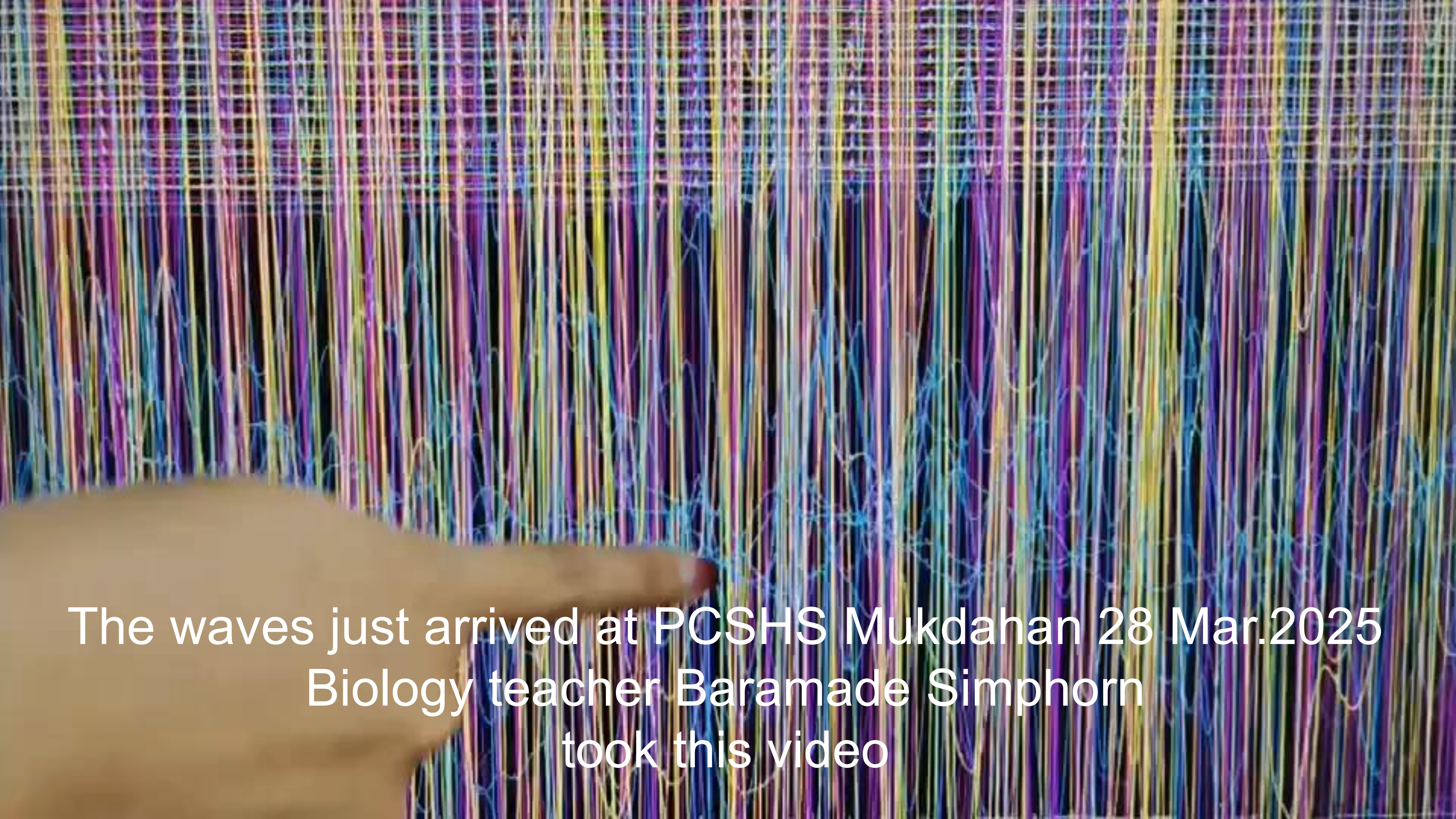
What's New (25 August 2025)

25th Aug. 2025 2025Kushiro_GeoMag Poster(E ver. Page2) New!
25th Aug. 2025 2025Kushiro_Thai_Seis Inner Earth(E ver. Page2) New!
2nd Mar. 2025 2025 Jan-Feb. Thailand SHS visit New!
19th Nov. 2024 Thin-Section Photo System New!
15th Oct. 2024 Covid-19 Infection Simulation Part 4 New!
06th Sep. 2024 About my lectures on Geoscience in Thailand New!
31th Aug. 2024 Comparison of micro-controlers
05th Aug. 2024 2022GeoSciEdiX_Matsue,Japan
16th July 2024 BM1422GMV Magnetometer
10th Jun. 2024 ESP32 Micro-barometer making recipe
08th Jun. 2024 Reminder for micro-barometer data processing
06th Jun. 2024 Reminder for magnetometer data processing
03rd Jun. 2024 Old BASIC program Museum
27th May 2024 How to add timestamps for serial data
16th May 2024 QMC5883L Geo-magnetometer (prototype)
07th Apr. 2024 Wave Propagation Simulations for Classrooms
25th Feb. 2024 ESP32 Seismometer (prototype)
24th Feb. 2024 SCiUS 2023 Symposium Presentation
28th Jan. 2024 2023Dec-2024Jan Thailand Diary Whole_List
24th Jan. 2024 MUIGC2014 Excursion Diary
21st Jan. 2024 Satun Geopark Excursion Diary
07th Dec. 2023 My Seismograph History

Resources
for Thailand schools
Conference Presenter
for the GeoSciEdIX
for the 5th KVIS-ISF
Old contents

Seagull Lab & Factory
Seagull Lab for Classroom
Seagull Factory
Thin-Section related
3D printer products

Old Misccerous
Old_Topics


The waves just arrived at PCSHS Mukdahan 28 Mar.2025
Biology teacher Baramade Simphorn
took this video

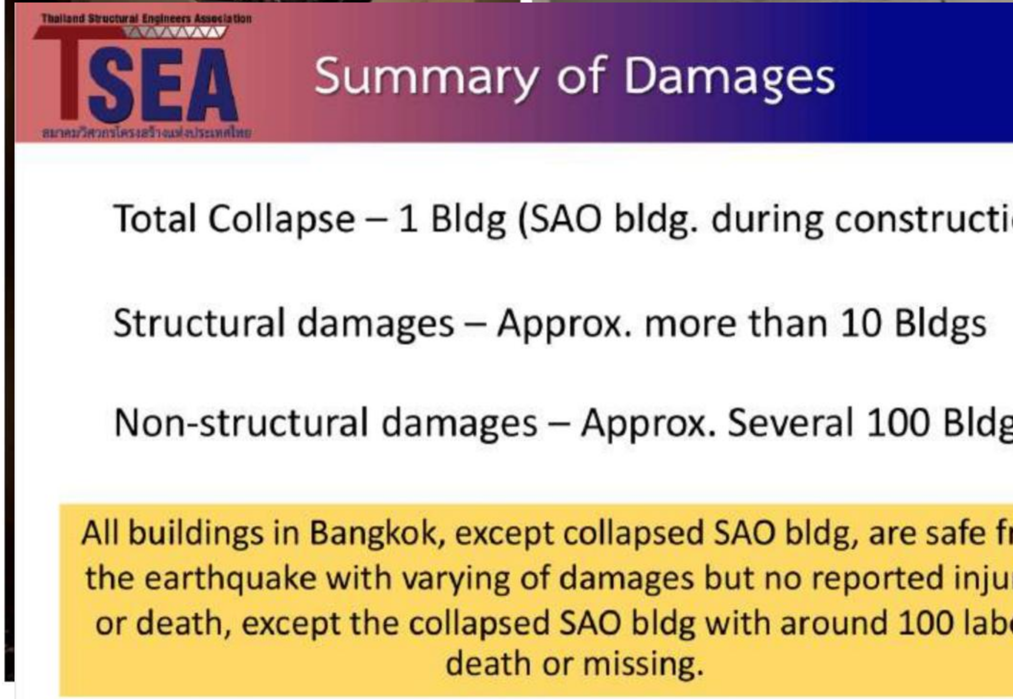
https://www.youtube.com/shorts/fXUPi8_BPzk

10min video recorded by Dr.Chachawal (Phayao Univ.)

/www.youtube.com/shorts/BWuk xZE3PA

Teraphan Ornthammarath et.al.2025

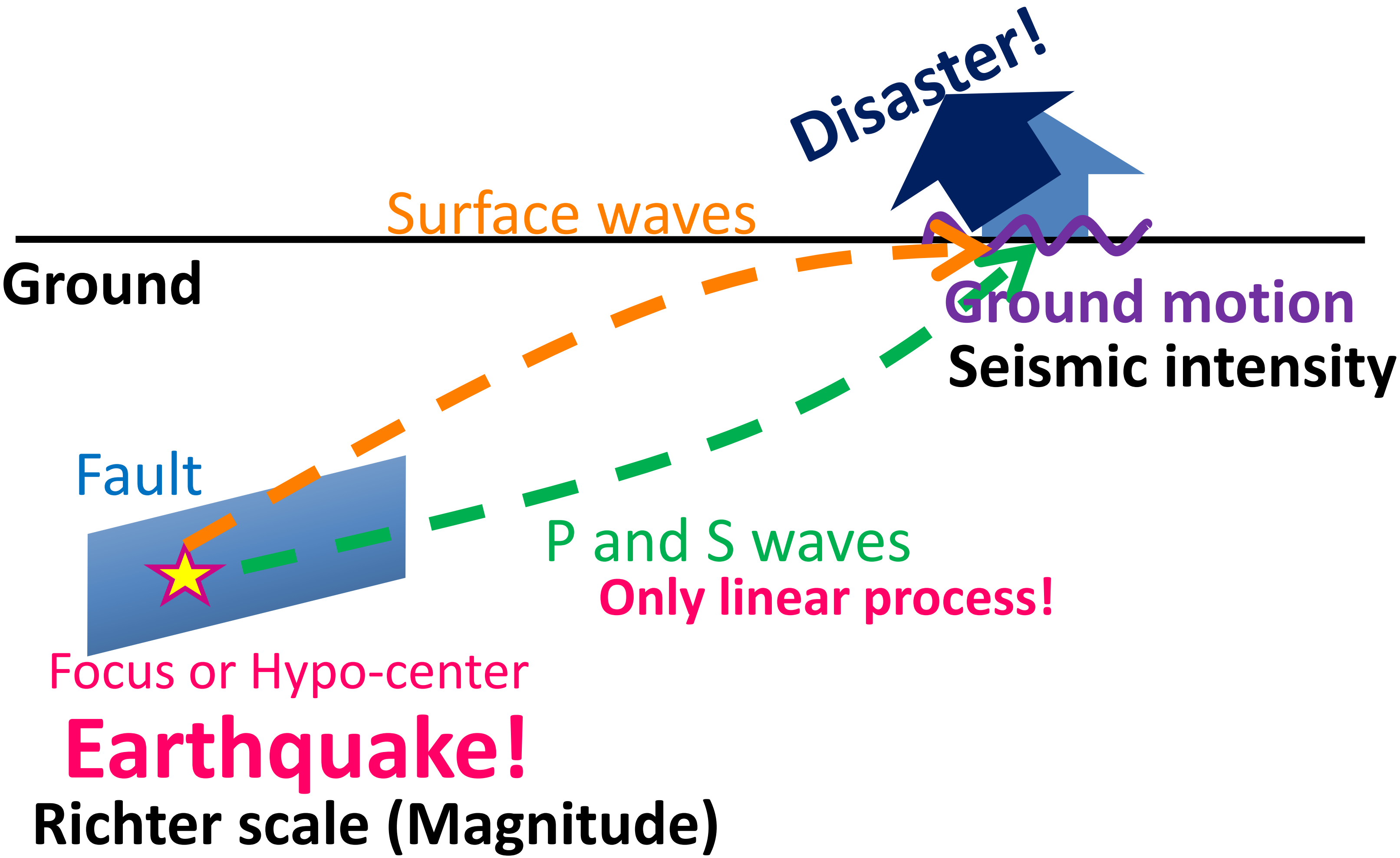
Fig. 15 Severe damage observed at shear wall including vertical bar buckling and concrete spalling in the lower stories of a 25-story building due to lack of seismic detailing with horizontal reinforcing bars of about 300 mm spacing



Pennung Warnitchai(2025)

Fig. 16 a) A partial failure of suspended ceiling in a high-rise building was commonly obse due to lack of horizontal bracing, b) non-structural damage to a large infill wall was also w indicating out of plane failure pattern from the boundary frame

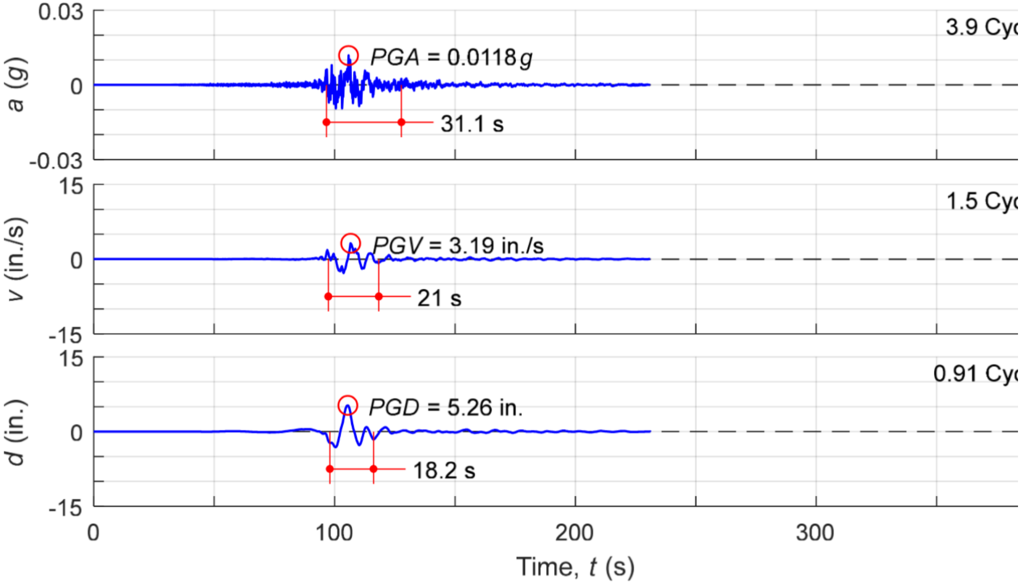
Earthquake: cause and result



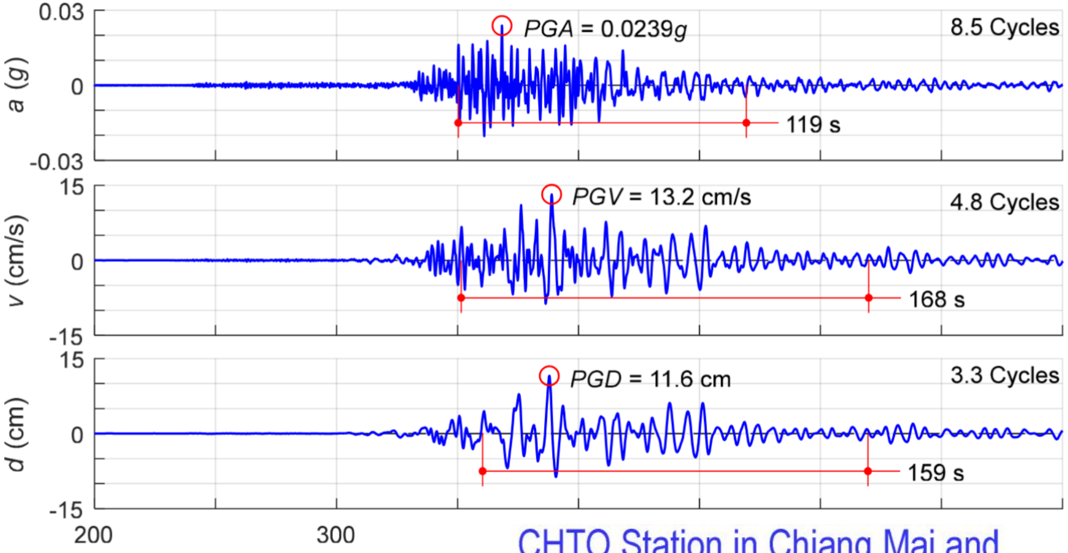
Why so strong shaking caused in Bangkok?

1) **Thick soft sediments** amplify the shaking
2) **The long period waves** survive at long distance.
3) Then, **Strong resonance** of the buildings caused due to the free oscillation periods.

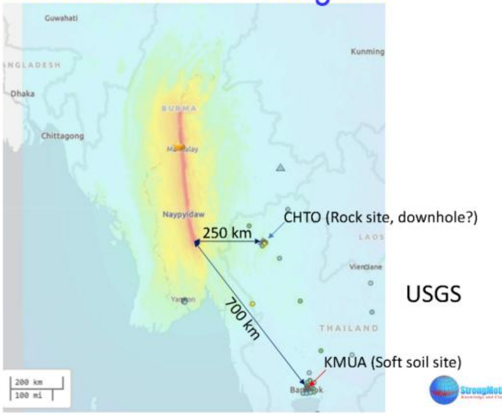
Maximum-Horizontal Ground Motion Histories — CHTO (Rock)



Maximum-Horizontal Ground Motion Histories — KMUA (Soft Soil)



CHTO Station in Chiang Mai and KMUA Station in Bangkok



Praveen K. Malhotra (2025)

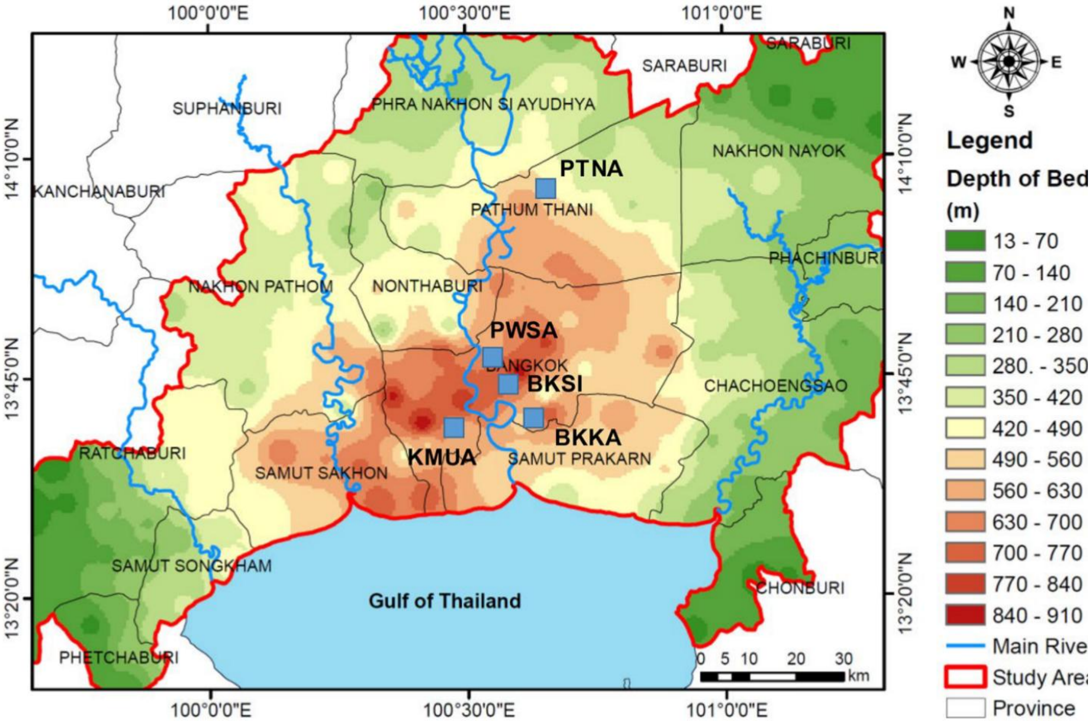


Fig. 3 Map showing five seismic stations located in the Bangkok basin and the depth to the bedroc (modified from Jirasakjamroonsri et al. 2018)

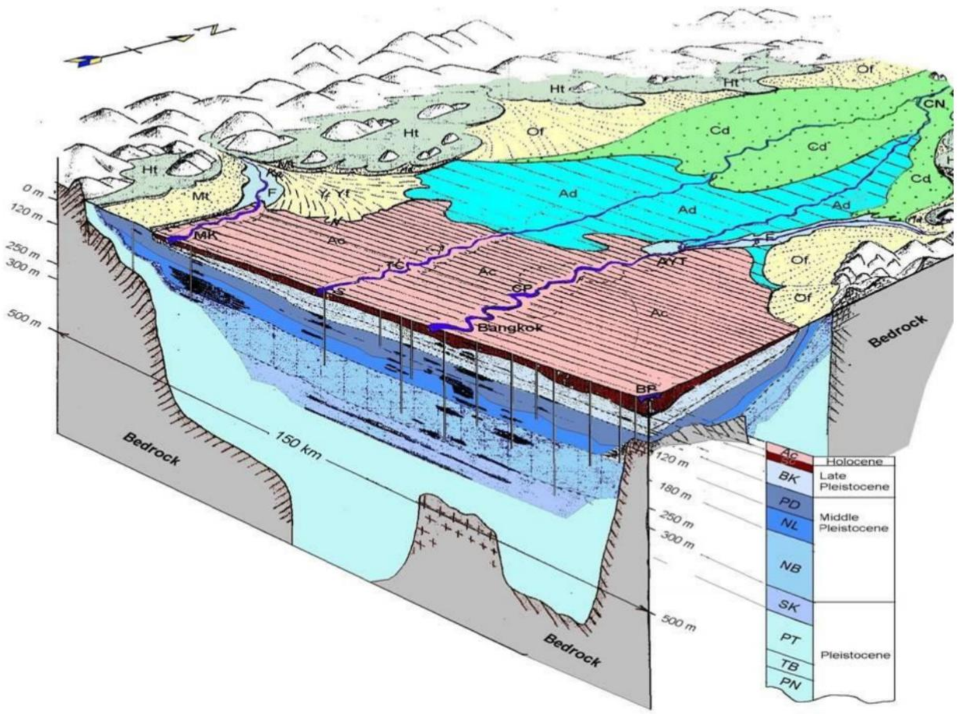
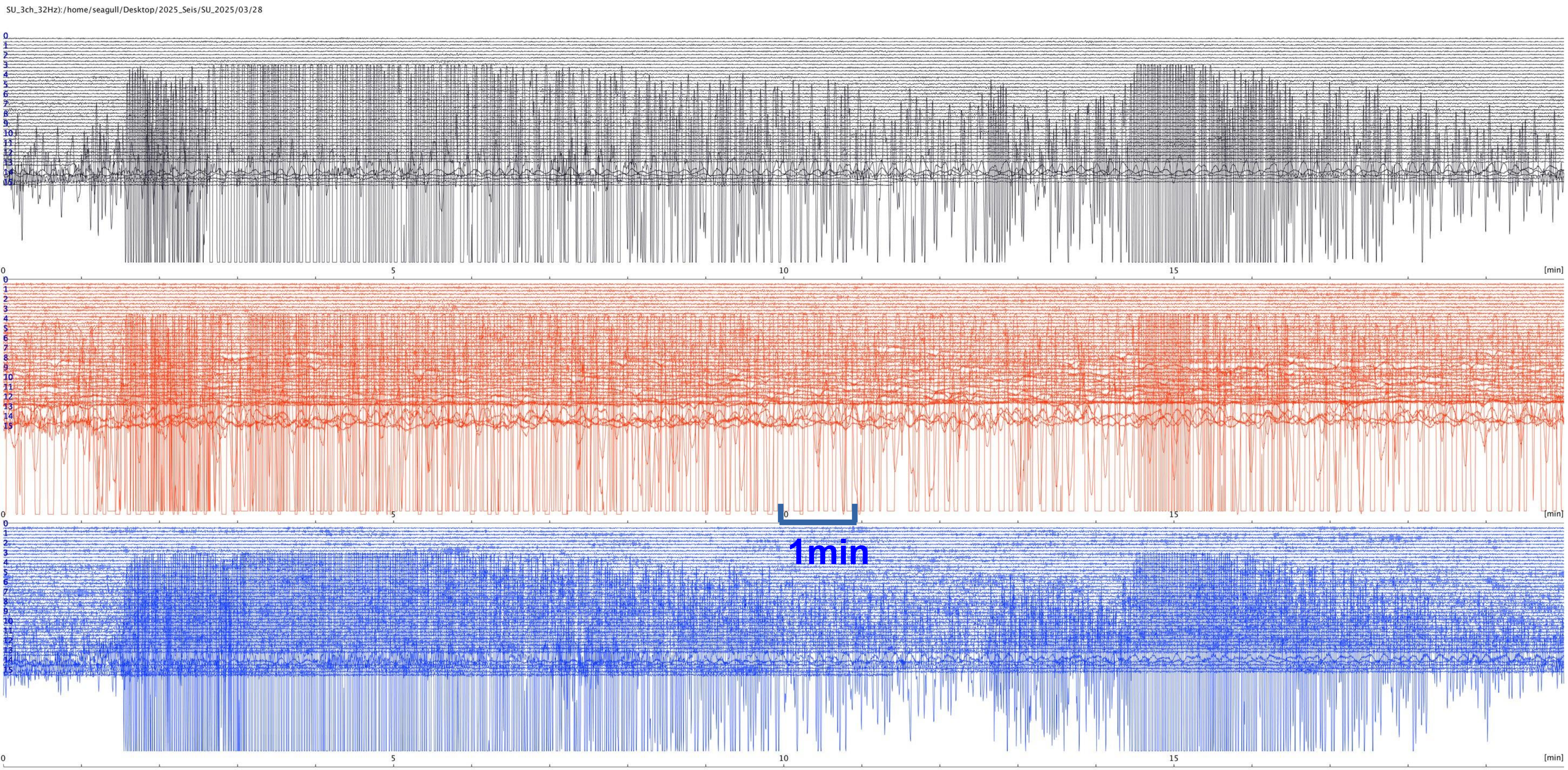


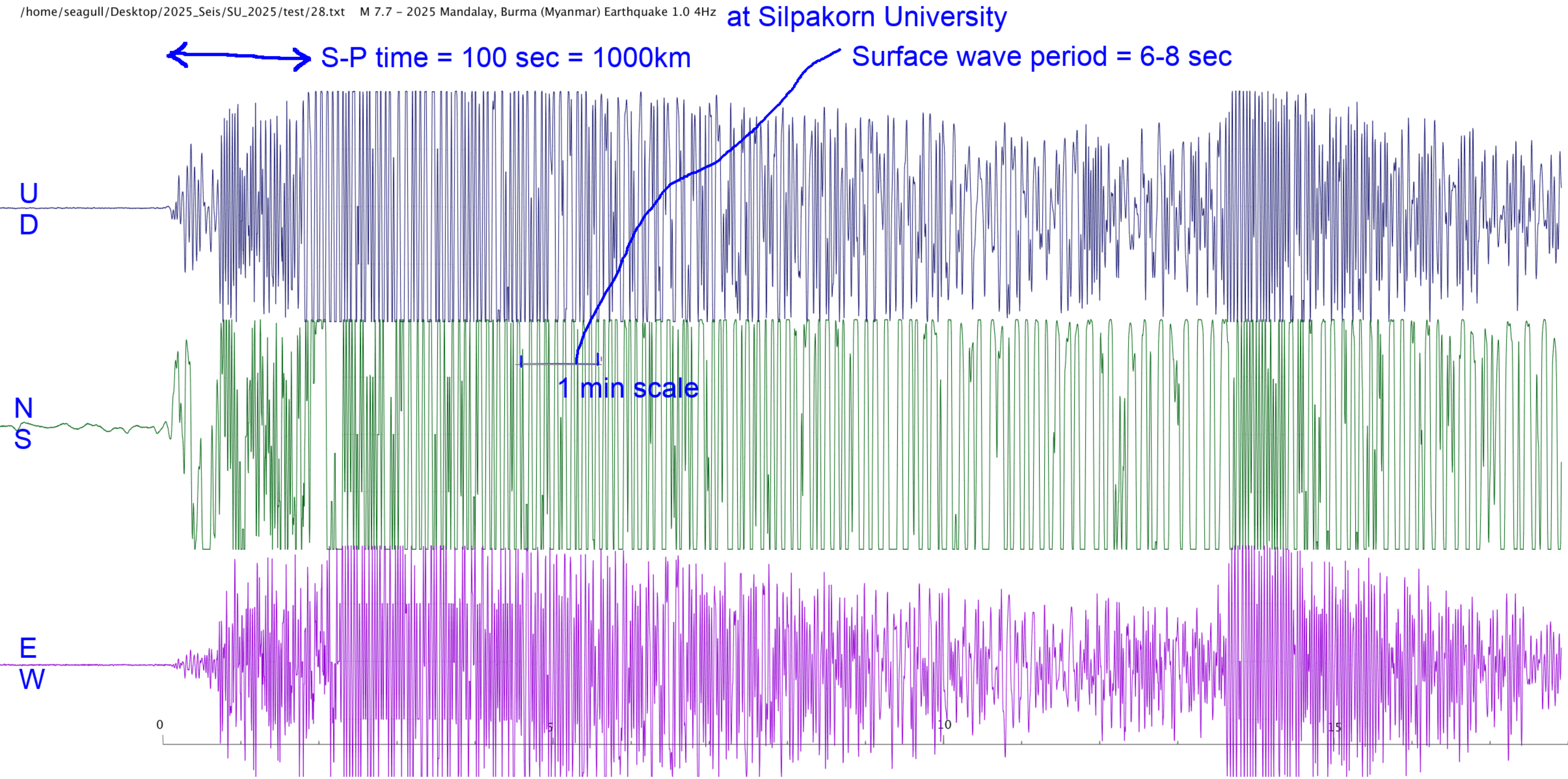
Fig.7 Schematic cross-section of lower Chao Phraya Basin (JICA, 1999)

Teraphan Ornthammarath et. al. 2025

https://www.gerd.eng.ku.ac.th/Paper/Paper_Other/Mairaing/%28EIT-Japan%29Soft%20Bangkok%20Clay%20Zoning.pdf

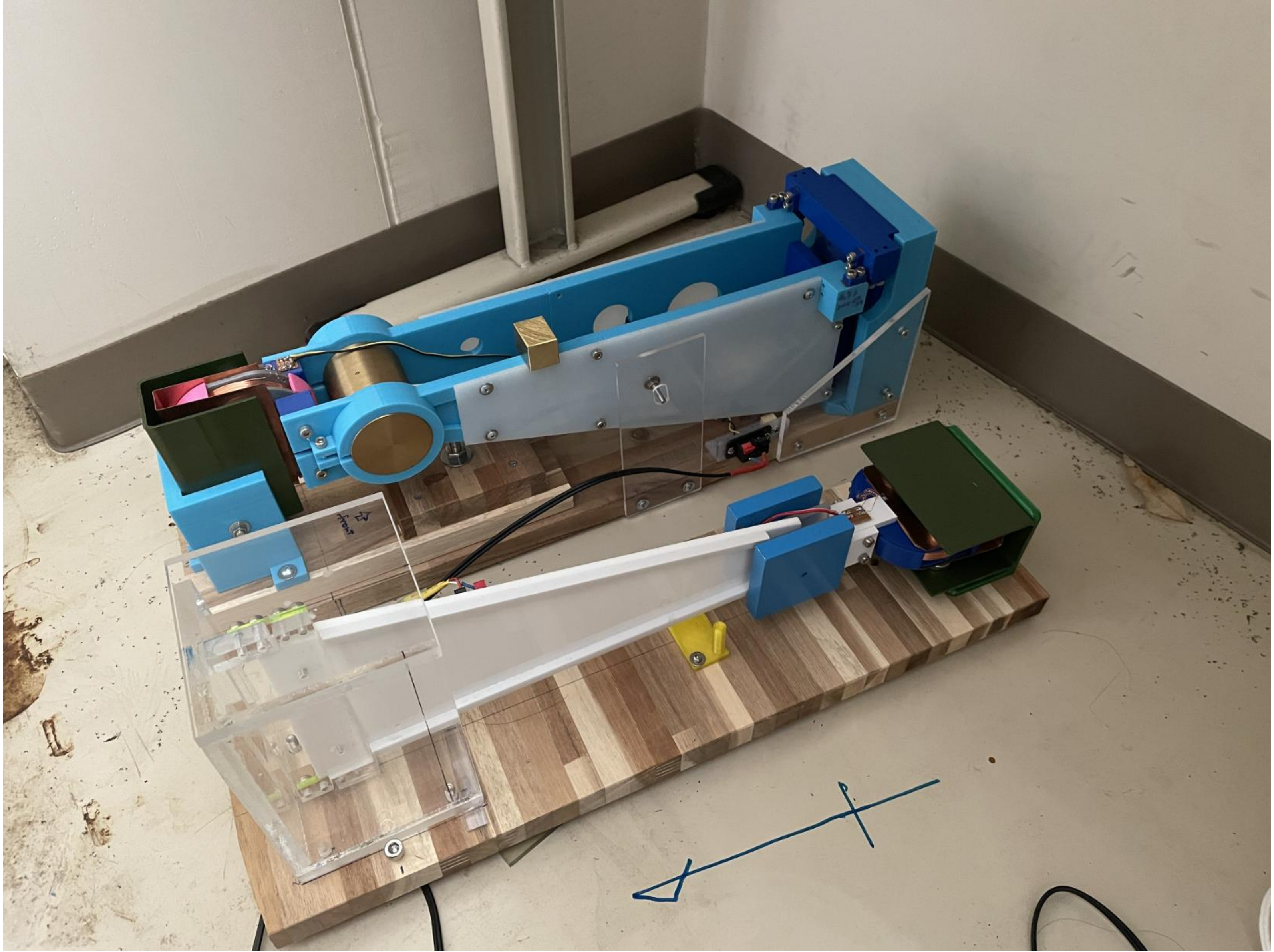
Our seismographs in Thailand
1000km apart from Epi-center
Prof. Ohm and our seismographs at Silpakorn Univ. Physics Labo.

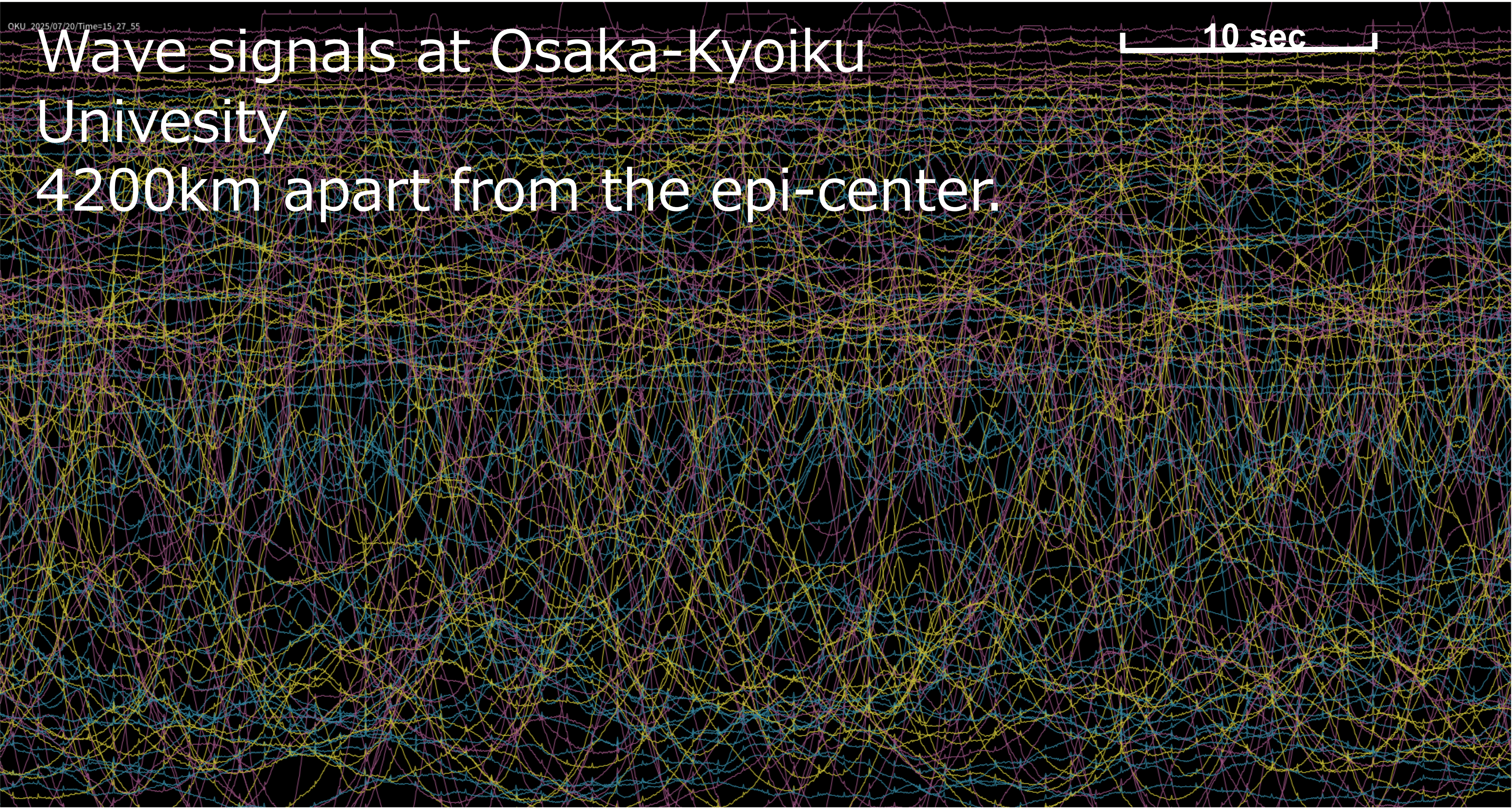

SU_3ch_32Hz):/home/seagull/Desktop/2025_Seis/SU_2025/03/28
0
5
10
15
[min]
1min



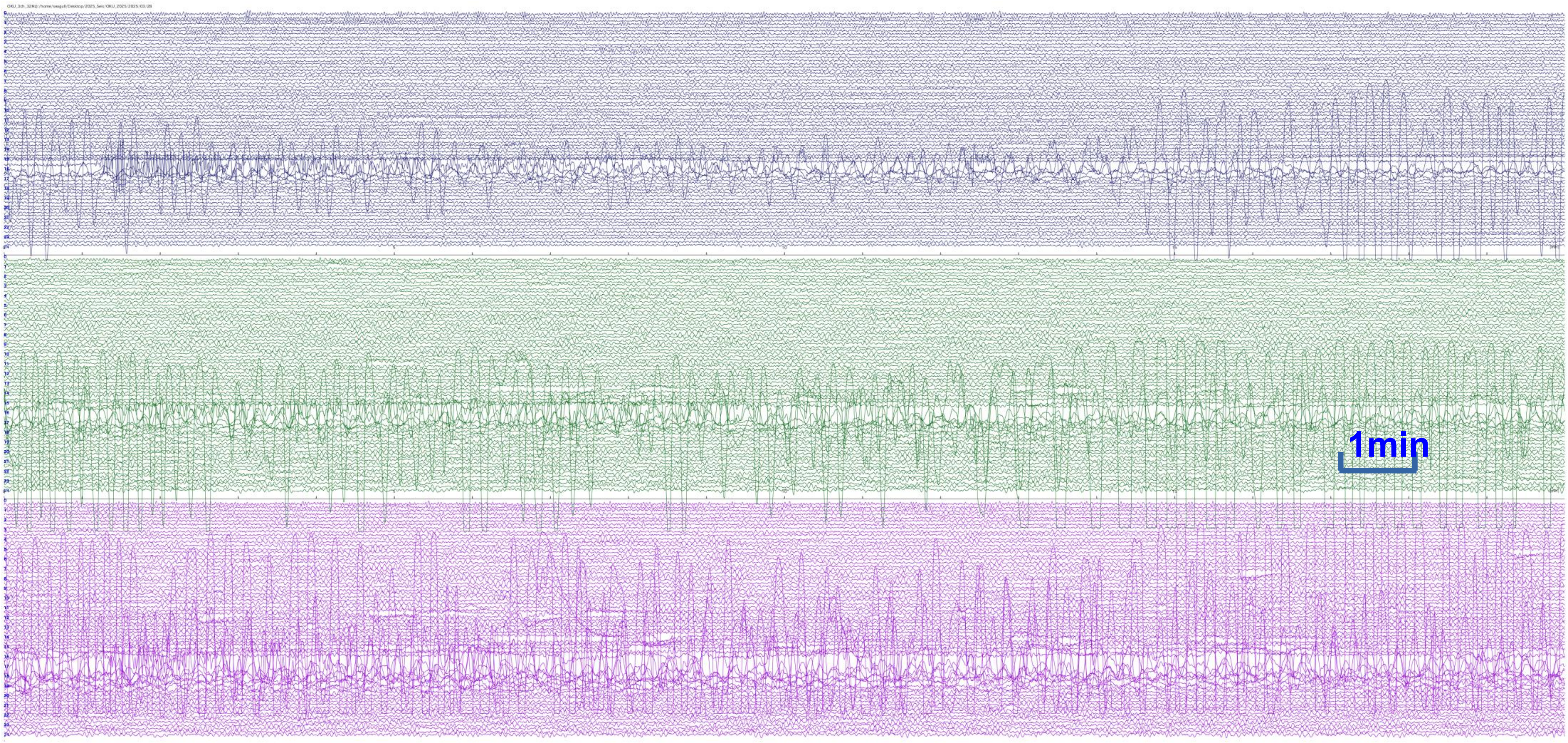
/home/seagull/Desktop/2025_Seis/SU_2025/test/28.txt M 7.7 - 2025 Mandalay, Burma (Myanmar) Earthquake 1.0 4Hz
at Silpakorn University
S-P time = 100 sec = 1000km
Surface wave period = 6-8 sec
U
D
1 min scale
N
S
E
W
0
5
10
15

Our seismographs in Osaka-Kyoiku Univ.
4000km apart from Epi-center

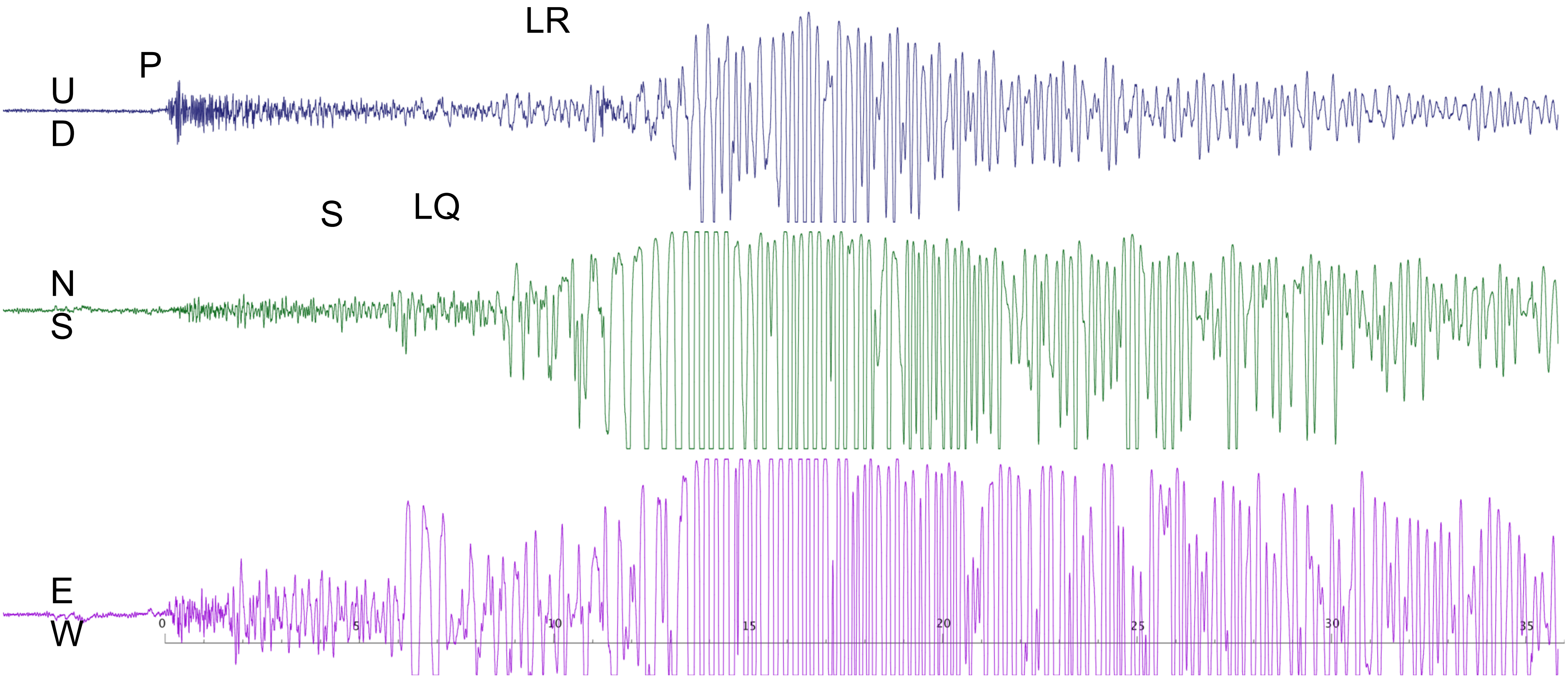



OKU_2025/07/20/Time=15_27_55
Wave signals at Osaka-Kyoiku Univesity
4200km apart from the epi-center.
10 sec

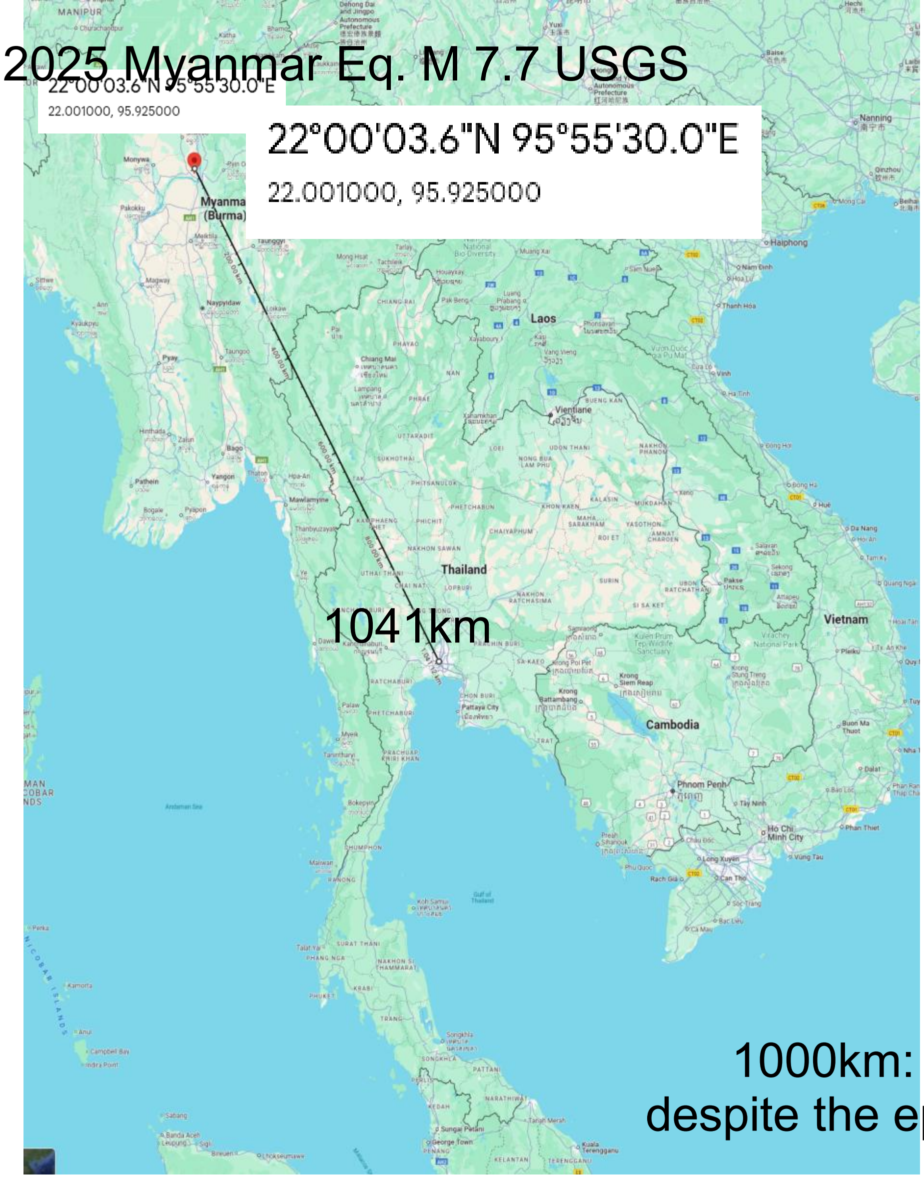
Whole day record on 28 Mar. 2025 at Osaka-Kyoiku Univ. JAPAN



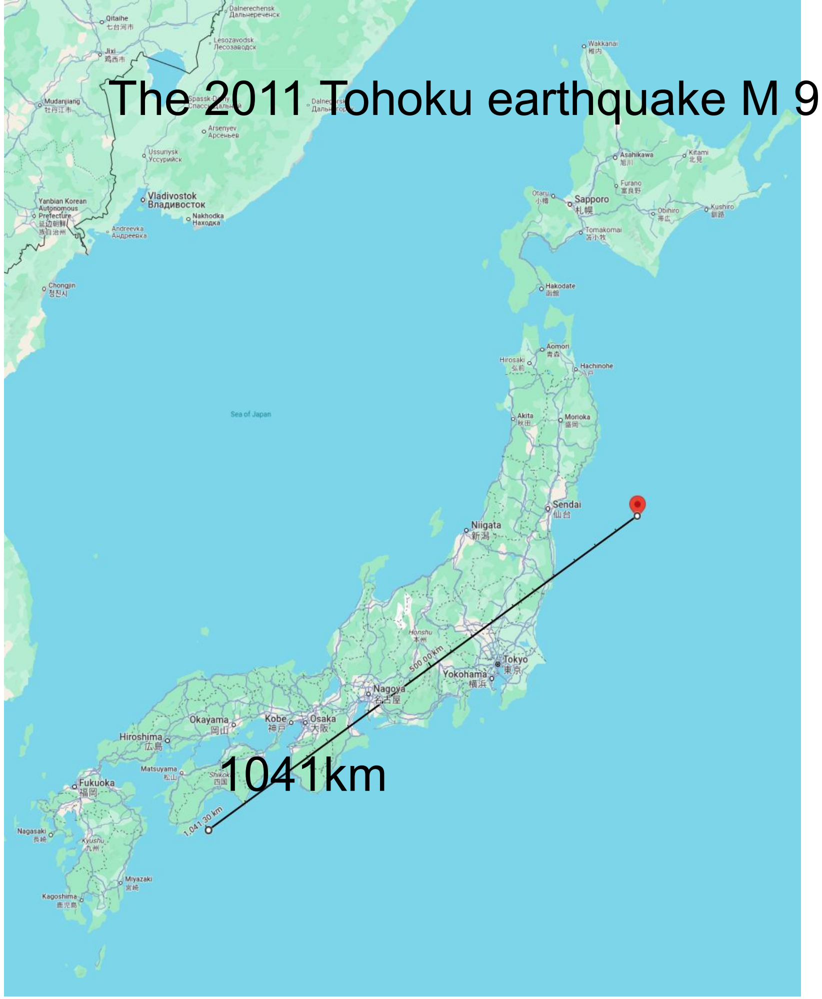
/home/seagull/Desktop/2025_Seis/OKU_2025/2025/03/28.txt M 7.7 - 2025 Mandalay, Burma (Myanmar) Earthquake



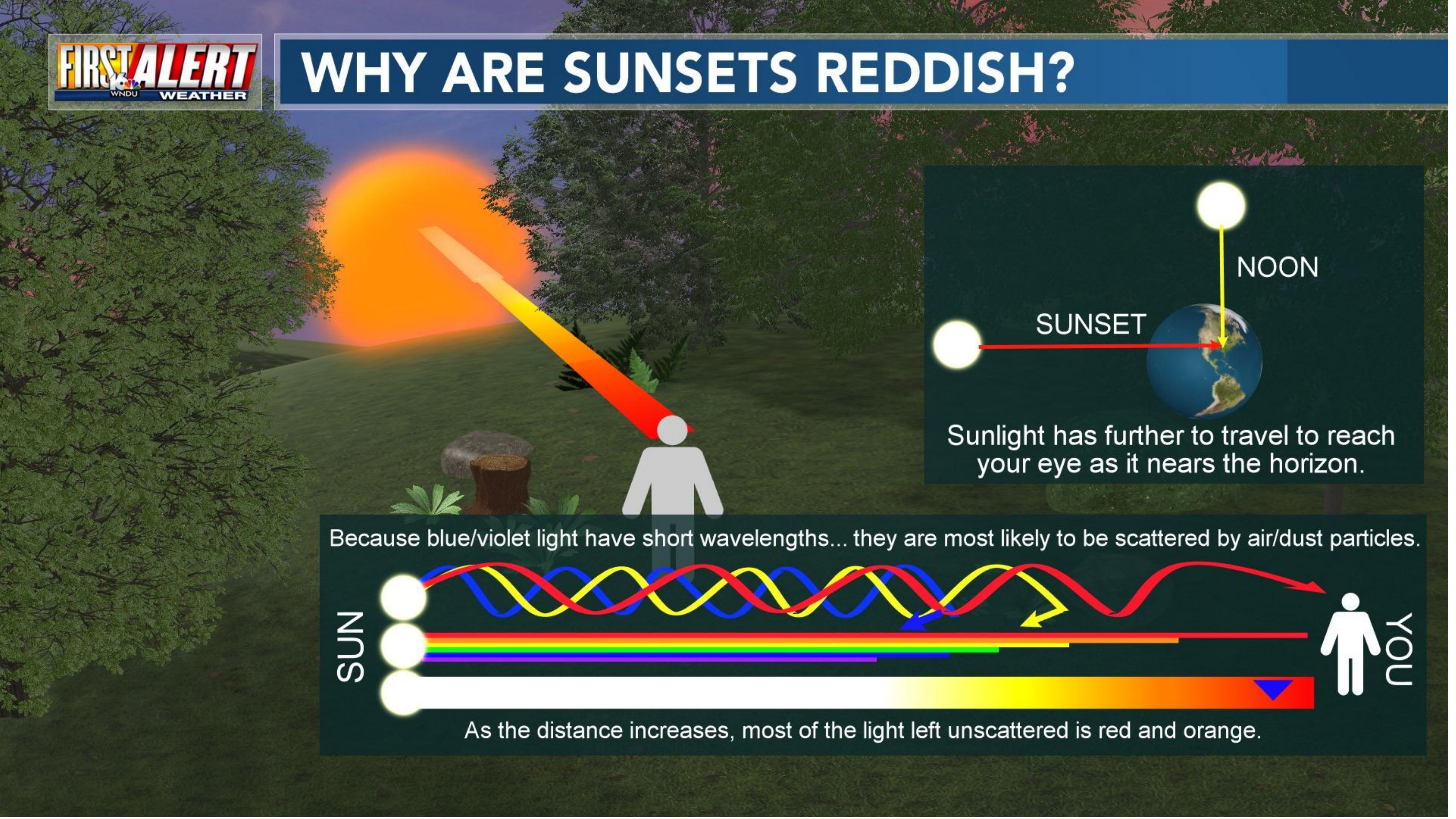
2025 Myanmar Eq. M 7.7 USGS



The 2011 Tohoku earthquake M 9.0



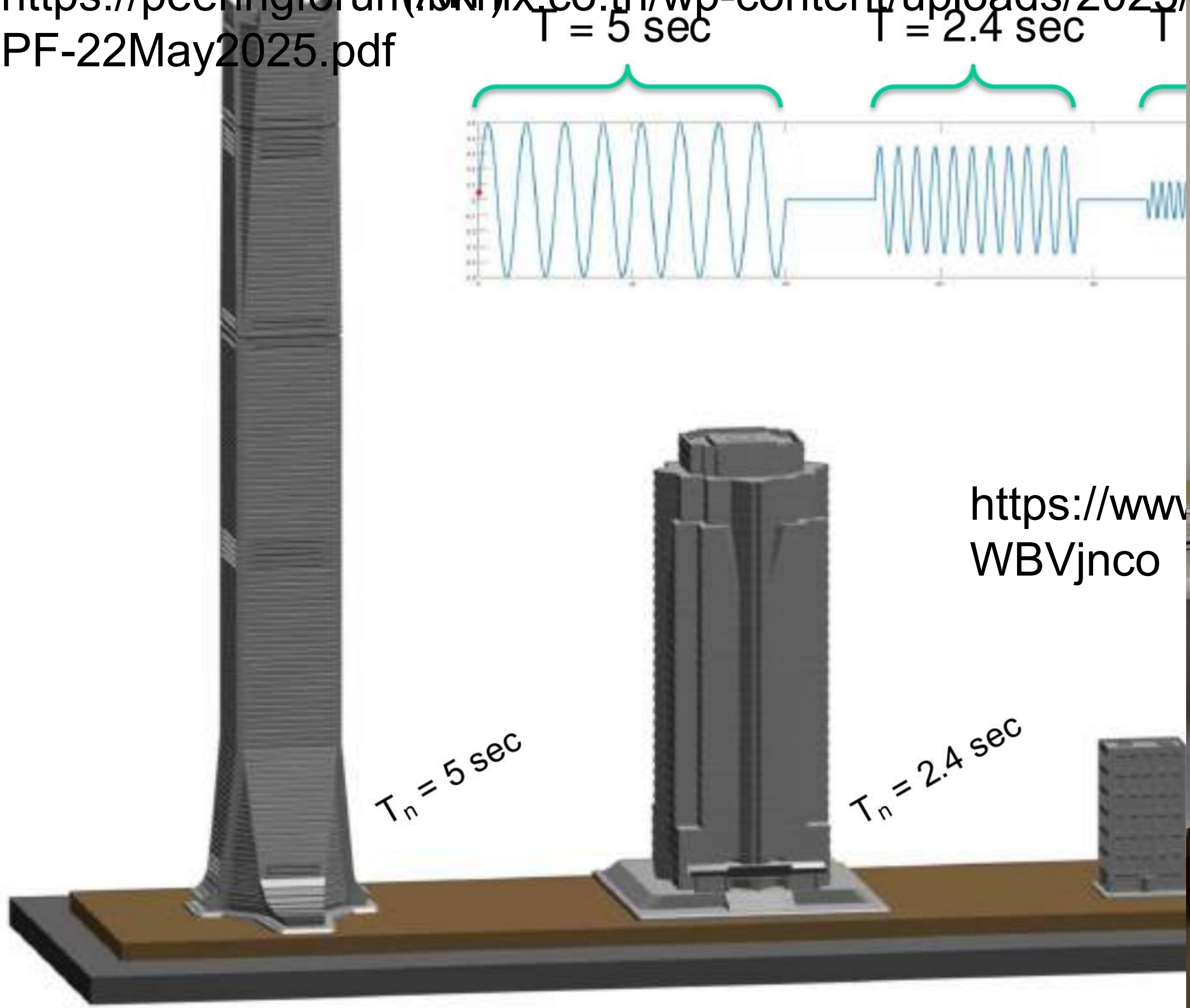
1000km: Why did damage occur
despite the epicenter being so far away?


FIRST ALERT
WNDU
WEATHER
WHY ARE SUNSETS REDDISH?
NOON
SUNSET
Sunlight has further to travel to reach your eye as it nears the horizon.
Because blue/violet light have short wavelengths... they are most likely to be scattered by air/dust particles.
SUN
YOU
As the distance increases, most of the light left unscattered is red and orange.

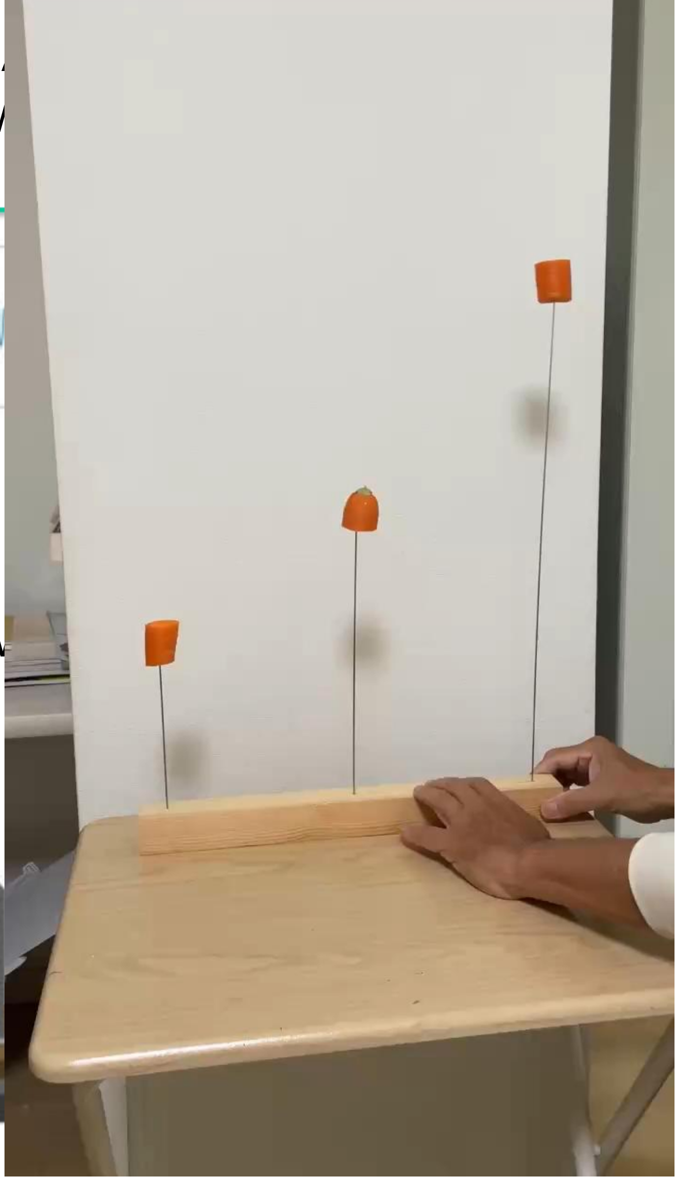
Resonance Effect

By Pennung Warnitchai, Professor of (AIT)

https://peeringforum.bknix.co.th/wp-content/uploads/2025/ PF-22May2025.pdf



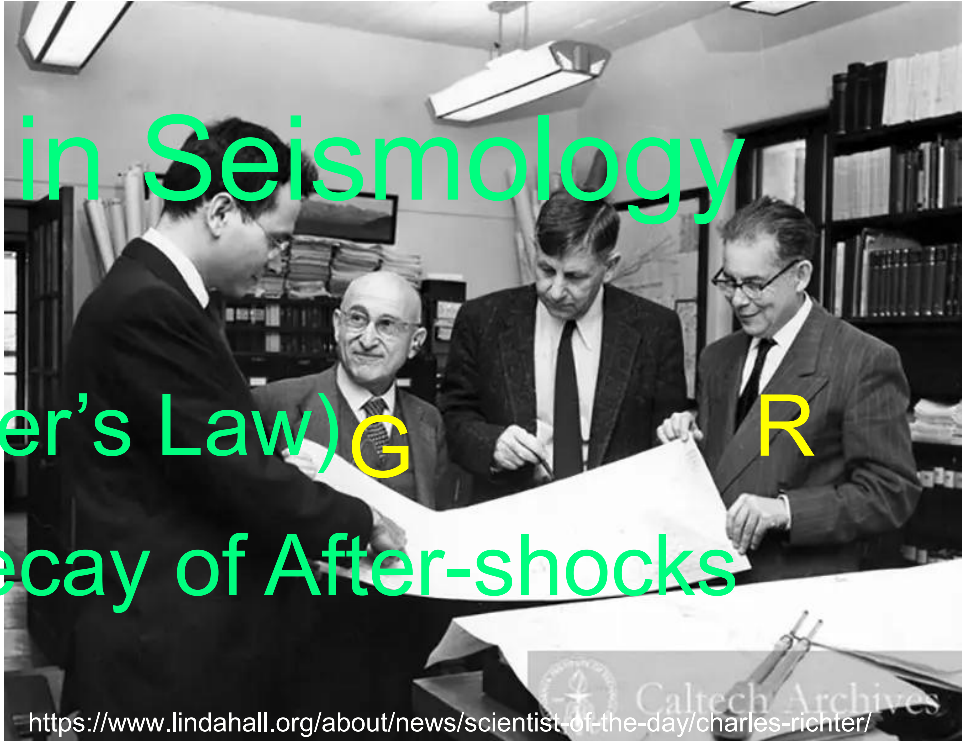
https://www WBVjnco



Go to “Boring” Statistics!

Two Empirical Laws in Seismology

- G-R Law (Gutenberg-Richter's Law)
- Omori Law: Exponential Decay of After-shocks



https://www.lindahall.org/about/news/scientist-of-the-day/charles-richter/

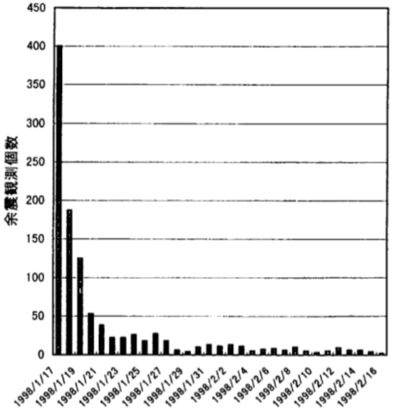


図１　表１のデータをグラフに示したもの（２／18以降は省略）

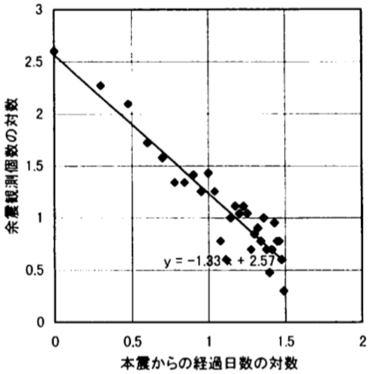


図２　図１のグラフの両軸を対数に代えたもの

Log-Log Plot -> Line: Power Law

Okamoto,1999

The Gutenberg-Richter's Law

- Earthquake-size: Magnitude(Size)
- Number of earthquakes (Frequency)
- Examples of South-East Asia and Japan
- Lets’ Try!

The Gutenberg-Richter's Law

- Earthquake-size: Magnitude(Size)
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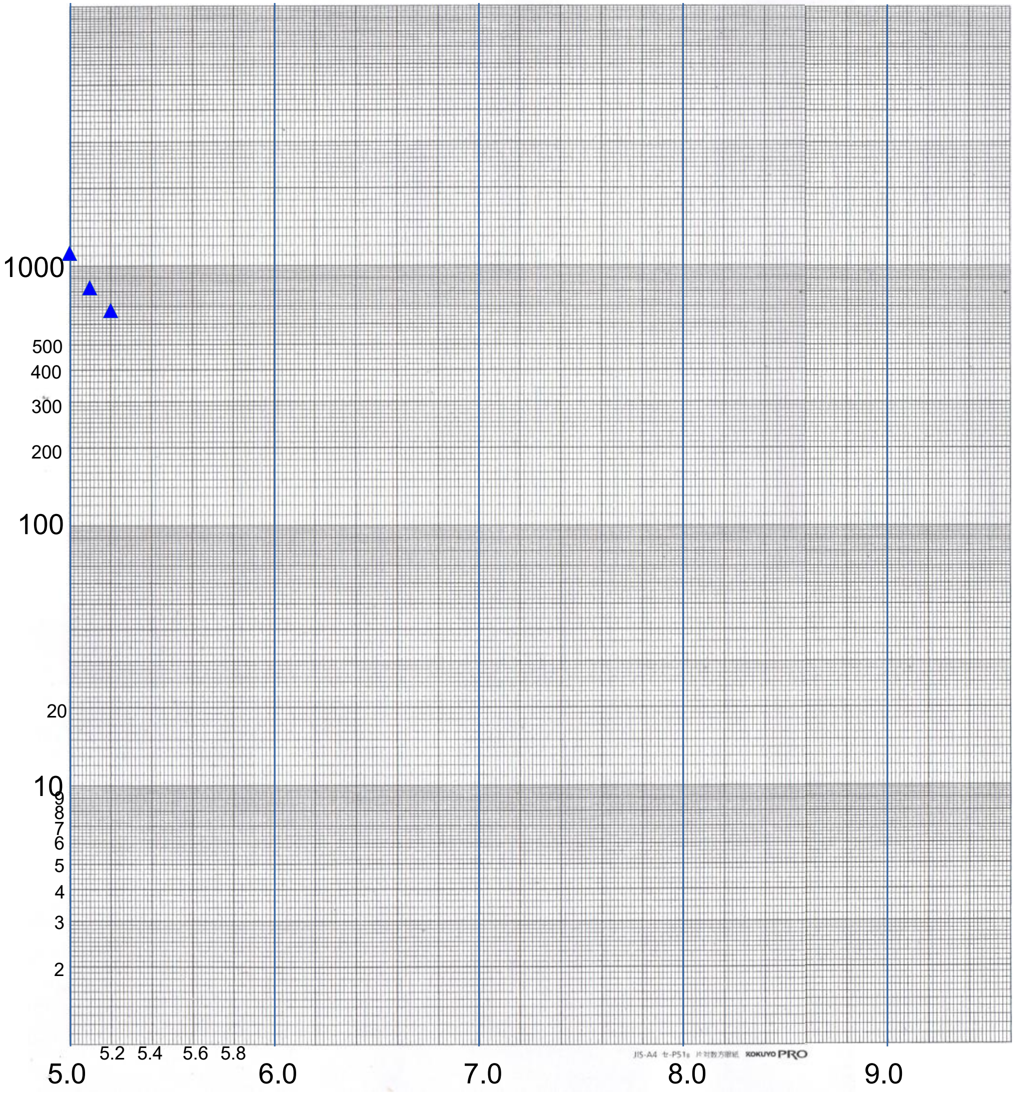
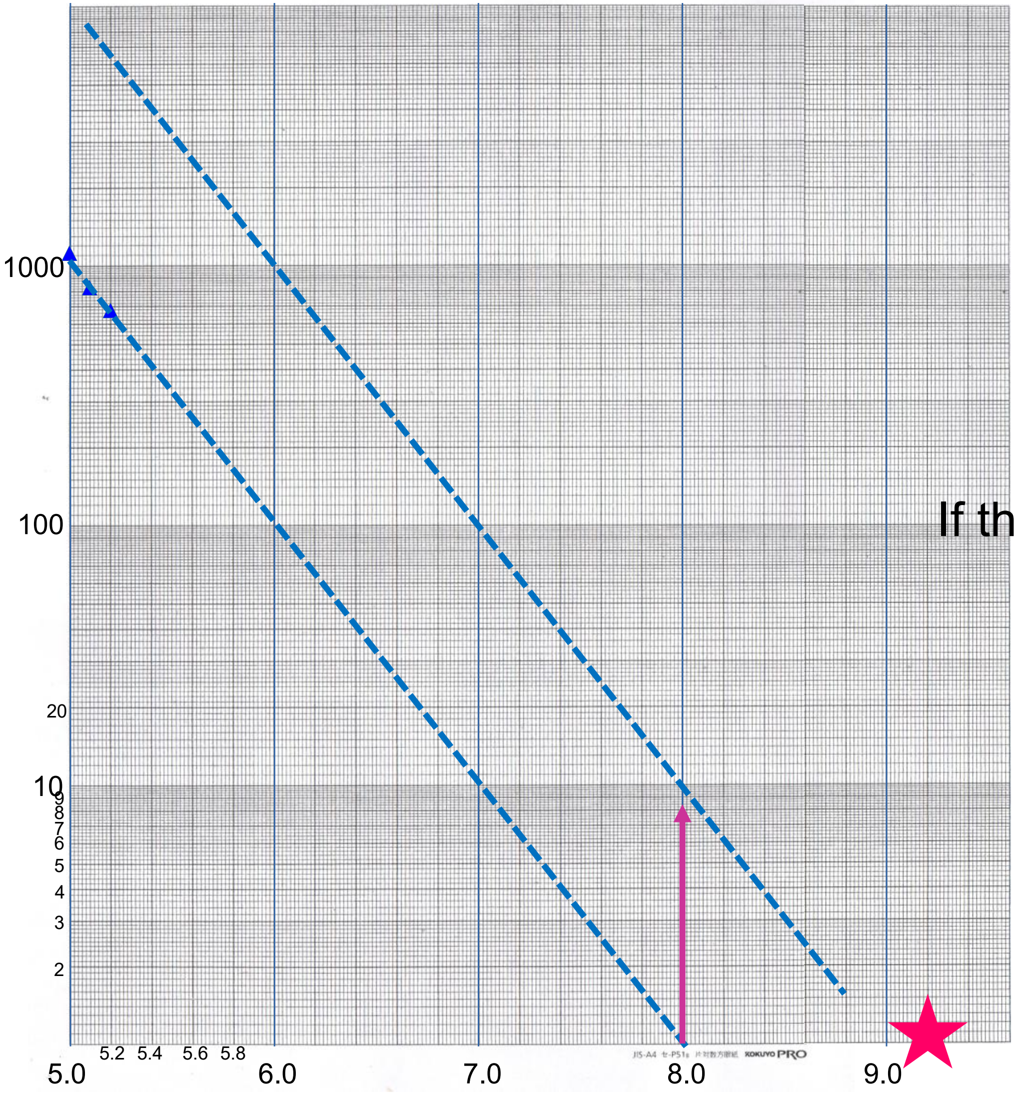


SE Asia2000-2019 85-130-0-30

5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
1113	806	676	495	375	272	188	188	112	98
6.0	**6.1**	**6.2**	**6.3**	**6.4**	**6.5**	**6.6**	**6.7**	**6.8**	**6.9**
72	61	37	42	23	16	14	9	11	11
7.0	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**	**7.6**	**7.7**	**7.8**	**7.9**
3	7	5	3	3	6	2		1	
8.0	**8.1**	**8.2**	**8.3**	**8.4**	**8.5**	**8.6**	**8.7**	**8.8**	**8.9**
		1				2			
9.0	**9.1**								
	1								

Japan 2000-2019	*125-150-25-50*

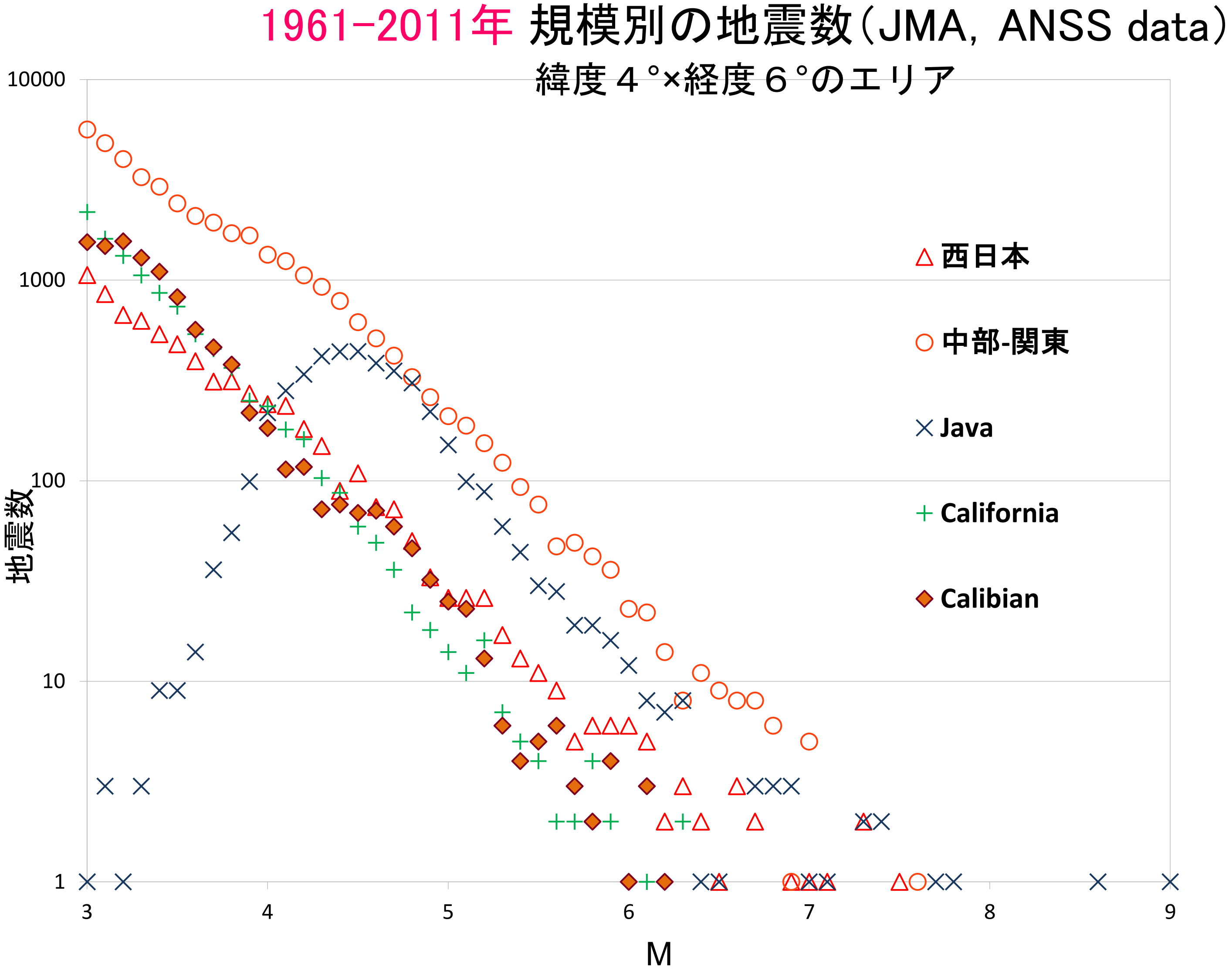
5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
455	314	241	171	126	115	79	78	59	49
6.0	**6.1**	**6.2**	**6.3**	**6.4**	**6.5**	**6.6**	**6.7**	**6.8**	**6.9**
31	33	29	22	8	10	4	6	3	5
7.0	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**	**7.6**	**7.7**	**7.8**	**7.9**
3	2		2	1			2	1	1
8.0	**8.1**	**8.2**	**8.3**	**8.4**	**8.5**	**8.6**	**8.7**	**8.8**	**8.9**
		1				2			
9.0	**9.1**								
	1								



If the period (20-years) chosen 10 times longer
What will happen?

There are two ideas
about out-ranged data

Dragon King!!


1961-2011年 規模別の地震数(JMA, ANSS data)
緯度４°×経度６°のエリア
10000
1000
100
10
1
地震数
3
4
5
6
7
8
9
M
西日本
中部-関東
Java
California
Calibian

Why G-R Law?

- Go-Game Model (Ohtsuka,1971)
- Sand-Pile Model (Bak, et.al.,1987)
- Spring-Block Model (Burridge and Knopoff,1967, Carlson and Langer,1989)

Go-Game Model (Ohtsuka,1971)

地　　震　　第 2 輯
第 24 巻 (1971) 215-227 頁

Q-2　地震の起り方のシミュレーション

第二部　地震の規模別頻度分布

熊本大学理学部物理学教室　大　塚　道　男

(昭和 46 年 6 月 30 日受理)

A Simulation of Earthquake Occurrence
Part 2. Magnitude-Frequency Relation of Earthquakes

Michio Otsuka
Department of Physics, Faculty of Science, Kumamoto University
(Received June 30, 1971)

At what stage of earthquake phenomena is the total amount of energy to be liberated by a particular event determined? Is it scheduled since long before the occurrence of that event, just before its outbreak or just after termination of disturbance?

Through detailed study of the operation of a simulator treated in the first part of this paper, the author was led to be interested in the plausibilty of the last case.

The basic idea is that the elastic stress energy spread over vast volume of rock medium cannot be liberated at an instant but must be released as a result of sequential progression of rupture which may be controlled by numerous factors such as stress concentration strength, inhomogeneity, distribution of flaws etc. in the medium.

The implication is that the amount of energy which is going to be liberated by a particular earthquake can only be told on the probabilistic ground until all energy release processes of that event are brought to termination. The observed magnitude-frequency relations of earthquakes are in general agreement with this argument.

§ 1.　は じ め に

さきに大塚 (1971, a) は，地震発生に関するいろいろな属性が，一つの機械的モデルを想定することによつて計算機の上にうまく simulate 出来ることを示した．たとえば，地震エネルギーの放出の模様，地震発生の時間的間隔，震源域の拡大などについて自然地震の発生に見られるさまざまな特徴が可成り巧みに再現されることを見た．この中で "地震の規模別頻度分布" の simulation についても成功の見通しがあることを示唆したが計算機のメモリーと計算時間の経済から結論を保留した．

本論文の目的は，"地震の規模別頻度分布" に焦点を絞り，その成り立ちのメカニズムをさぐる所にある．

さて，本題に入るに先立つて筆者が simulation をあつかつた論文 (大塚 (1971, a)，以下論文

昭和 46 年 5 月 20 日地震学会で発表

作させればよい．このことは原理的には正しいが効率から考えると著しく損である．われわれの simulator が有効に働らくためには構成ブロック数を格段に増す必要があり，その上計算時間も甚し[illegible]する必要であると思われるからである．

そこで，地震の規模を支配している要因と思われる連鎖反応の機構だけを simulator から抽出することによつて別のモデルを作り，このモデルについて検討を加えることにする．次の一節は，その新らしいモデルを紹介するために費やそう．

§ 2.　碁石モデル

Fig. 1 を参照して，まず碁板の中央に一つの白石が置かれている状態を考える (A)．この白石を囲む点は a, b, c, d の四点である．今これらのそれぞれについて一回ずつ一つのサイコロを振る権利が与えられ，もし 6 の目が出れば，それに対応する点に白石をおく．6 以外の目が出れば黒石をおくと約束する．今仮りに a に対応して 6 の目が，その他三回は 6 以外の目が出たとすると石の配置は (B) のようになるであろう．次のステップでは更に新らしい白石のまわり，すなわち e, f, g でサイコロを振る権利が与えられる．その結果，g に対応して 6 の目が，他は 6 以外の目が出たとすると石の配置は (C) のごとくなる．第 3 ステップでサイコロを振る権利は h, i に与えられる．その結果，もし 6 の目が一回も出なかつたとすると石の配置は (D) のようになる．白石三ケは完全に黒石に包囲されてしまつたから第 4 ステップではサイコロを振る権利がない．この状態で一回のゲームは終る．上の例の場合の得点は囲まれた白石の数，すなわち 3 点である．ここであらためて (A) の状態からゲームをくり返す．

さて，このようなゲームを何回も繰り返すうちに得点の頻度分布がはつきりして来るであろう．それはどんなものだろうか．

碁石モデルを simulator と対比してみるに，白石が一つ置かれることは一つの辷りが起つたことに対応し，黒石が置かれることは辷りの波及がそこで喰い止められたことを意味する．

当然のことであるが，simulator の中である辷りが発生し，それがどの程度成長するかは，その構成要素たるバネの強さ，摩擦力の大きさ，過去に経験した辷りの履歴等をすべ

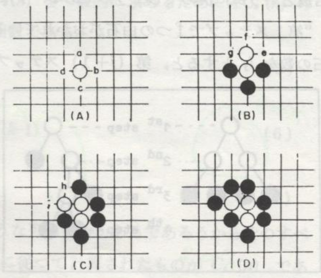


Fig. 1.　An example showing how "Go game model" simulates the progression of rupture in the medium. Each progression of rupture is assumed to be determined by probabilistic processes.

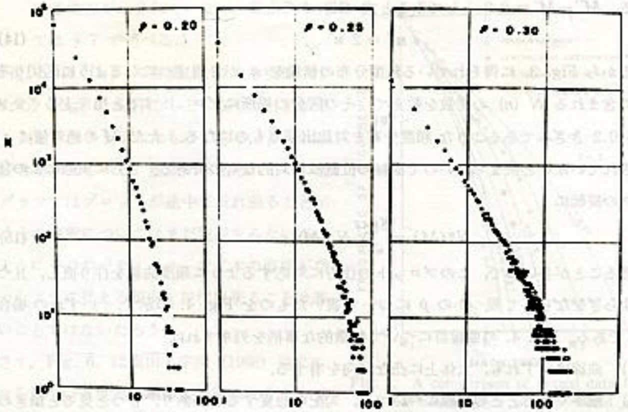


Fig. 3.　The calculated output of "Go game model" for various values of p, a parameter which controls the probability of rupture propagation.

程として捉えたことの正しさを示している．しかも試行回数が桁違いに多いのに比して計算時間は著しく短かい．

この議論を一歩進めて，われわれの解を地震の規模別頻度分布と対比してみたい．そのためには Fig. 3. の横軸の目盛り方を少し変更して地震のマグニチュードに対比出来るものにせねばならない．そこでふたたび論文（1）の立場をとつて，一つの白石（すなわち一つのブロックの辷り）から発生する地震エネルギー ε は一定であるとすると n ケの白石の塊から得られる地震エネルギー E は

$$E = n\varepsilon \tag{9}$$

で与えられる．故に

$$\log E = \log n + \log \varepsilon \tag{10}$$

である．またエネルギー E と地震のマグニチュード M の間には

$$\log E = 1.5\ M + 11.8 \tag{11}$$

の関係があるから式 (10) と (11) から E を消去すると

$$\log n = 1.5\ M + (11.8 - \log \varepsilon) \tag{12}$$

を得る．今 M' に対する n を n'，M'' に対する n を n'' とすると式 (12) から

$$\log\ (n''/n') = 1.5\ (M'' - M') \tag{13}$$

する曲線が示されていない．理由については § 7 で述べる.)

Fig. 5. は（b）に指摘したことを明確にするため，Fig. 4. を作るもとになつた計算結果の一例をそのまま示したものである．$p = 0.32$ の場合を示している．観測からえられるこの種のグラフではプロットが途中で折れ曲ることが多くその解釈についてはまだ定説をみないがこのように一つのパラメーターで二本の直線が交わつたように見える傾向を説明出来ることは著しいことではないだろうか．

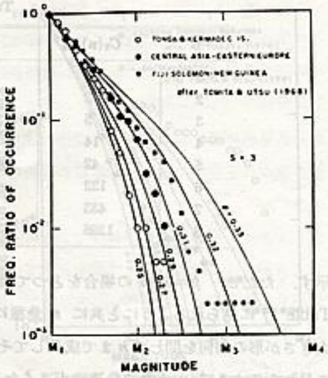


Fig. 6.　A comparison of actual data from various regions of the world with the result of "Go game model". Note that plots in each symbol are in fair agreement with general trends of theoretical curves of any parameter. This type of frequency distribution is onmed "type A" in the text.

さて，Fig. 6. は富田・宇津 (1968) 論文に載せられている世界各地の規模別頻度分布のデータから三例を拝借して碁石モデルの頻度曲線に重ねたものである．各記号はそれぞれ地域別を表わすが，各々がいずれかの p に対応する曲線でよく説明されるのが認められる．富田・宇津の論文に挙げられている例のうち一部を除いた殆んどはこの型に属しているように見える．また，ここに一々述べるいとまがないが地震の規模別頻度分布は概してこの型式をもつているのではないだろうか．とすれば，地震の規模別頻度分布の大部分は碁石モデルのパラメーター p を適当に選ぶと説明出来ることになる．観測データに式（1）をあてはめたのではプロット全体の傾向を説明出来ないことに注意してほしい．

さて，こうした目で地震の規模別頻度分布を調べてゆくと中には p の選び方だけではどうにもならず計算結果から大幅に外れるものがある．M の大きい部分で計算から大きく右へ張り出すものである (Fig. 7. 参照)．そこで Fig. 6 のように p の選び方で何とか説明のつく頻度曲線の型をA型，Fig. 7. のような型をB型と仮称して以下の節でそれぞれの成り立ちを考察してみたい．

§ 6.　A型頻度分布

式（4）によつて $P_s(n)$ のふるまいは $C_s(n)$ と $(pq^{s-1})^n$ によつてきまる．今 $s = 2$ の場合について $C_2(n)$，$(pq)^n$ および $P_2(n)$ を $n = 1 \sim 8$ につき計算したものを Table 1. に

2.1 Go-game Model (Rules)

(Okamoto,2003)

http://seagull.stars.ne.jp/2003_Canada/web/index.html

"Go-game" is a popular stone puzzle game in Japan imported from ancient China.
"Go-game model" was originated by M. Ohtsuka in 1971 to investigate the background of "Gutenberg-Richter's Law", which is a famous relation between earthquake sizes and frequencies.

-Preparation:

* A lattice printed-paper.
* A pencil: Maker's logo shows hit.

(The probability of hits is 2/6 (p.p=0.33), see Fig.1). This article uses "p.p" as a propagation probability.)

-Procedures:

1) A cell is chosen randomly with a star<*> (start point of a fault break) (Fig. 2-a)
2) Four nearest neighbors are numbered (Fig. 2-a).
3) Dice trial; hit plots O and blank plots X. O means a break propagates while X means doesn't (Fig.2-b).
4) Sites surrounding O without any marks are numbered for next trial (Fig. 2-c).
5) The process is iterated until all sites are surrounded with X (end of an "earthquake").
6) If our virtual earthquake "finished", then an next earthquake will start. <Return to 1)>
7) After some practice time, the results of all students are gathered and summed on a blackboard, then are plotted on a log-log graph.

Fig.1 A lattice paper and pencils
(Left shows hit, right shows blank).

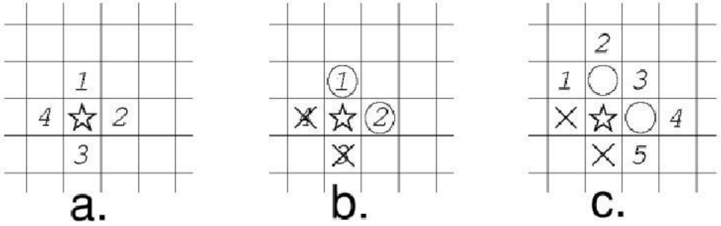


Fig.2: Rules of Go-game model.

Simulation Rules:

1. **Start:** Mark a random square with a star (⋆).
2. **Test:** Check the 4 neighbors (Probability p≈1/3).
    - **Hit:** Mark **O** (Continue).
    - **Miss:** Mark **X** (Stop).
3. **Repeat:** Test the neighbors of every new **O**.
4. **End:** Stop when the cluster is blocked by **X**s.

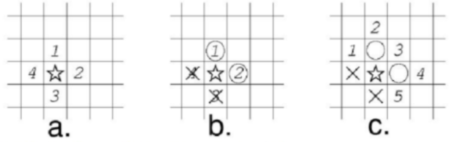
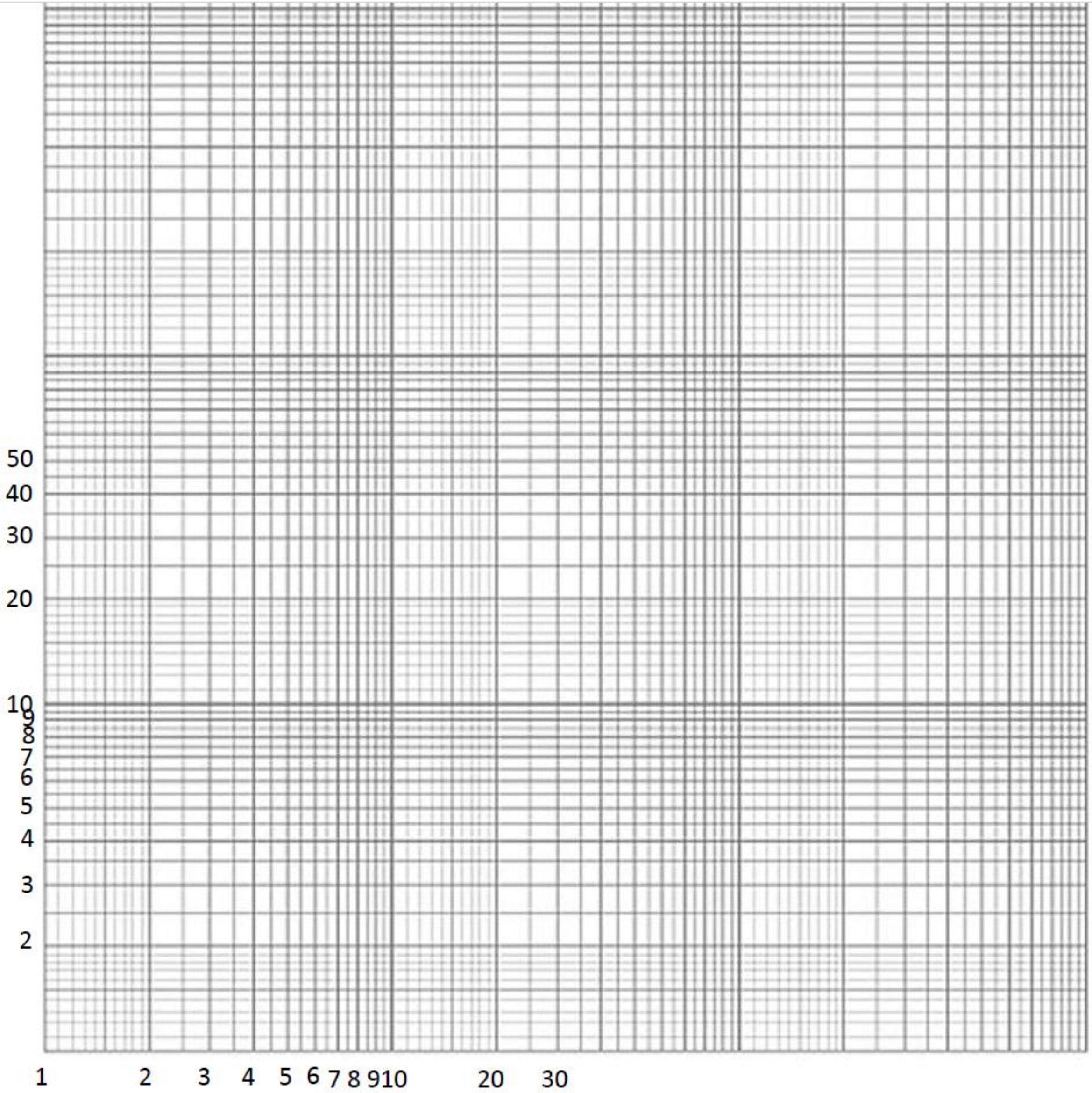


Fig.2: Rules of Go-game model.

My lecture at Osaka-Kyoiku Univ.(2017)


50
40
30
20
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8
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1
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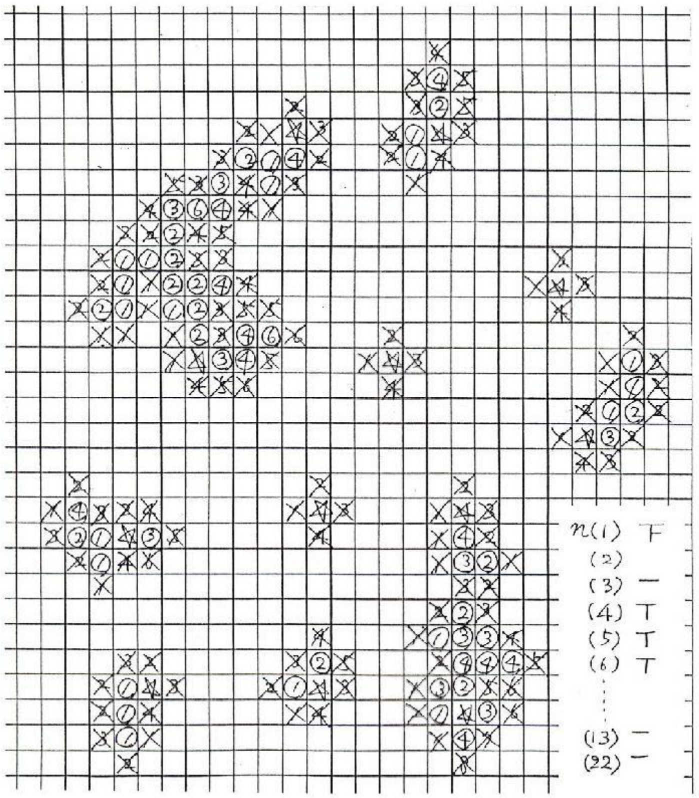
9
10
20
30

2.2 Board Game as a Student Practice



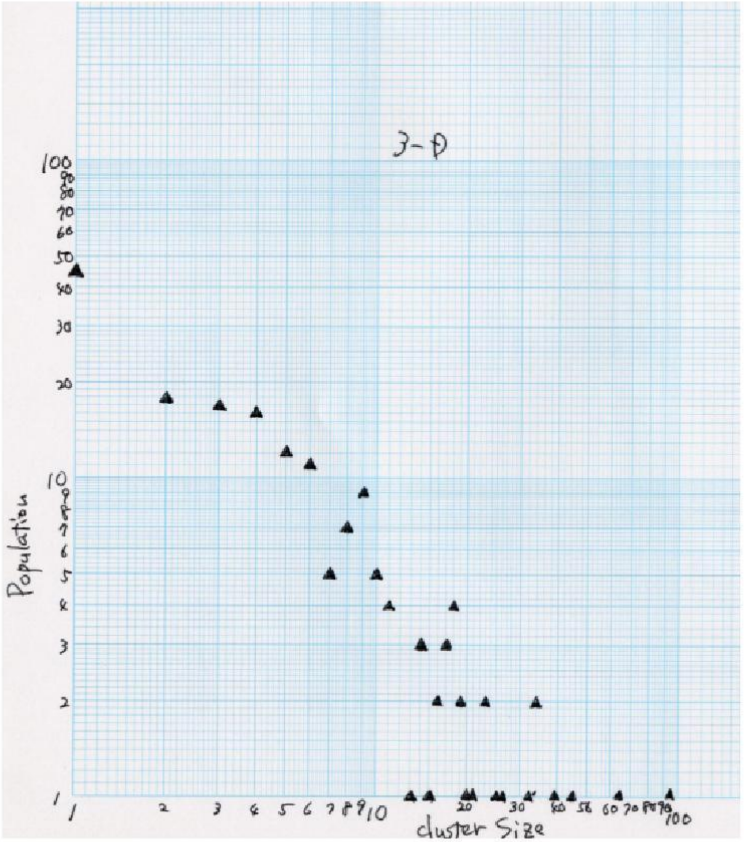
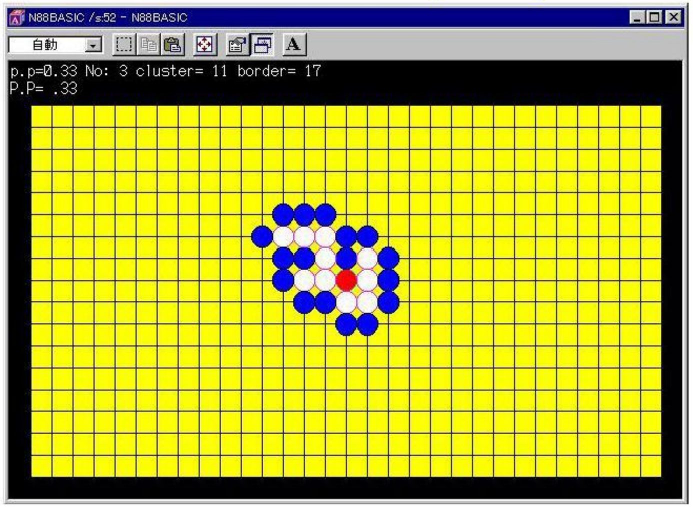
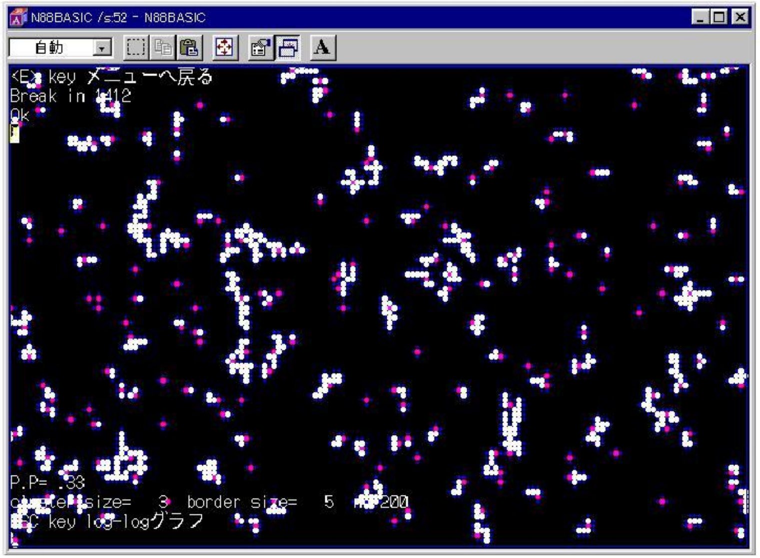


Fig. 3: Go-game model by hand trials (left)
and an example of cluster sizes vs. populations with p.p=0.33 on a log-log sheet (right).
A similar relation like the G-R law is appeared.

2.3 Go-game Model (Behavior)

- The number of break cells = an earthquake size.
- The more hit marks, the more earthquake grows.
- A similar relation like the G-R law.
- PC simulation: shows the real-time growth of clusters and the size-frequency relation.





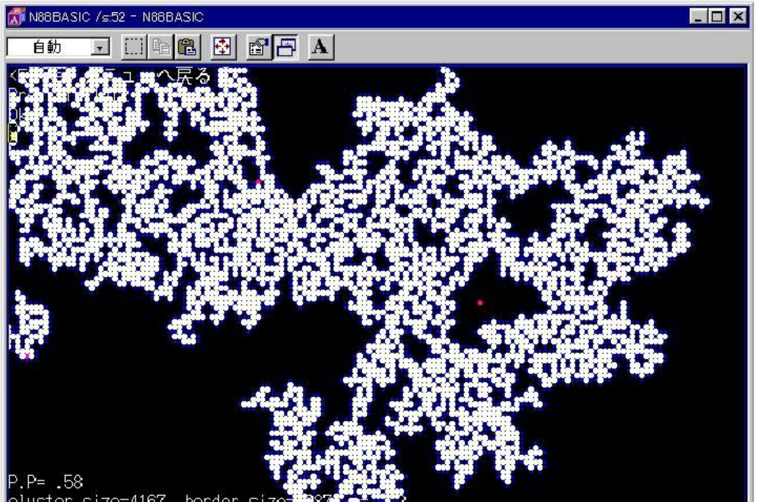
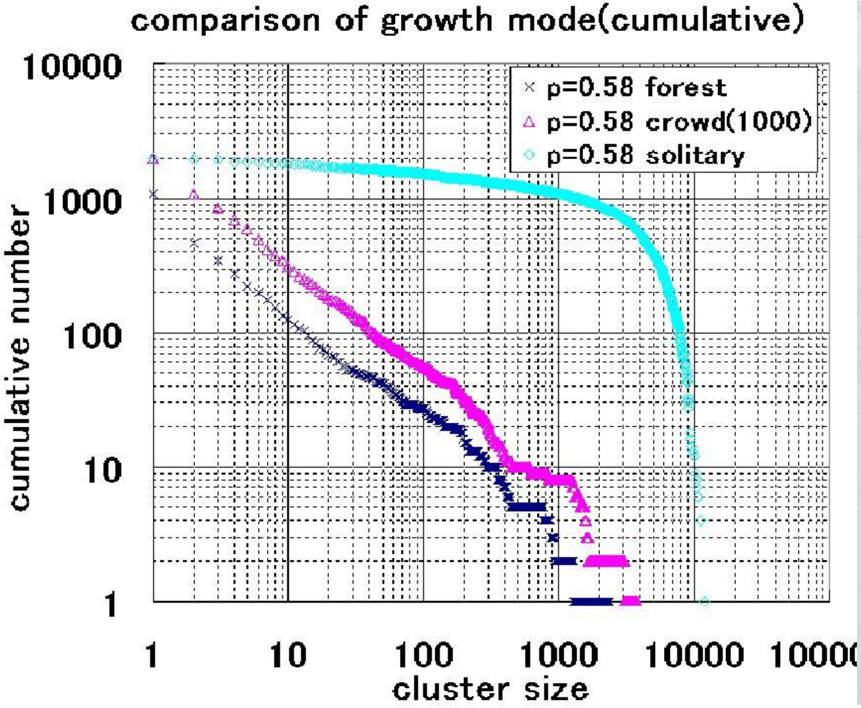
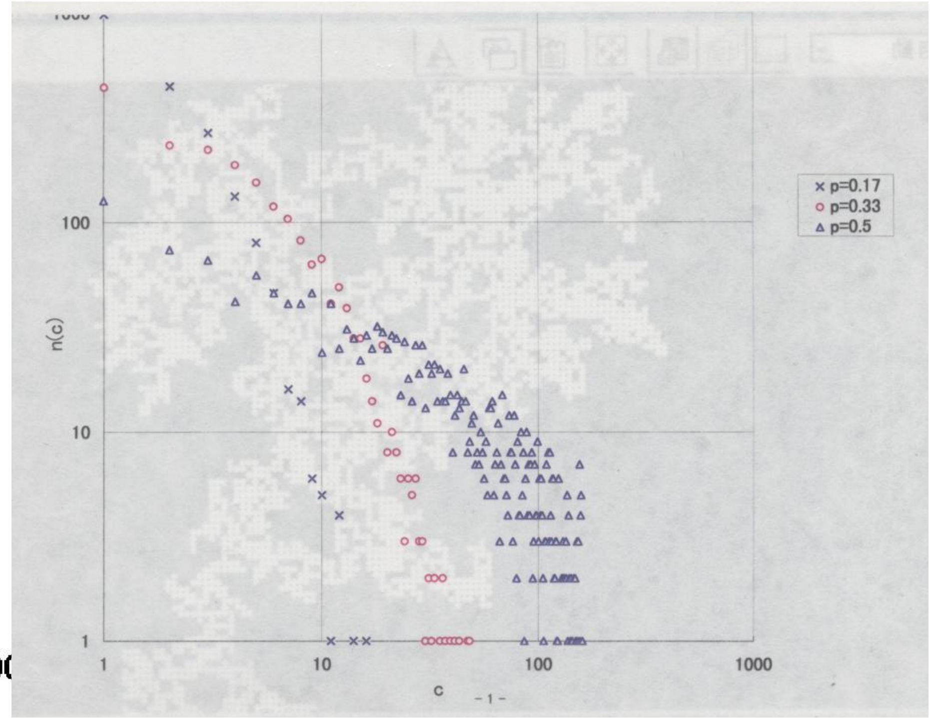


Fig.4 Demo_version on PC (left) and comparison with p.p (right): p.p=0.33(upper), 0.58(lower)

2.5 Earthquake Sizes vs. Frequencies





(Left) Fig.6: Virtual Earthquake sizes vs. Frequencies;
Propagation Probability p.p=0.58 (near critical state of 2 dimensional site percolation)
Clear linear relations, distinctive Fractal scaling behavior, appear in both the crowd mode and the forest mode, while the solitary mode does not show such character.
(Right) Fig.7: Natural Earthquake sizes vs. Frequencies (G-R Law Relation)

Disease Model

Shodor > Featured > DiseaseModel > Disease Model

Introduction Model Learner Instructor Help

NEW! **- View ASL annotated model of the spread of disease**

This model can be used to create a virtual population to observe how different factors might affect the spread of a disease. Scientists often use computer models to study complicated phenomena like epidemics. This model can be a simplified simulation of any disease that is spread through human contact. Find accompanying materials for students and instructors by using the links in the light blue navigation bar.

Oι

Ebola spreads slower, kills more than other diseases

http://www.washingtonpost.com/wp-srv/special/health/how-ebola-spreads/

This simulation shows how quickly 10 diseases, from more fatal to less fatal, could **spread from one person to 100 unvaccinated people.**

Newly infected   Recovered   Deaths   **Day 78**   RUN NEW SIMULATION

Ebola

DAYS ELAPSED	74
PEOPLE INFECTED	100
DEATHS	70

Smallpox

DAYS ELAPSED	42
PEOPLE INFECTED	100
DEATHS	30

Measles

DAYS ELAPSED	25
PEOPLE INFECTED	100
DEATHS	27

SARS

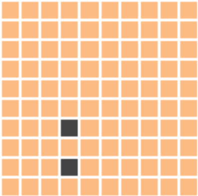
DAYS ELAPSED	47
PEOPLE INFECTED	100
DEATHS	11

Diphtheria

DAYS ELAPSED	77
PEOPLE INFECTED	43
DEATHS	7

Flu

DAYS ELAPSED	14
PEOPLE INFECTED	100
DEATHS	2



Whooping cough

DAYS ELAPSED	45
PEOPLE INFECTED	100
DEATHS	0

Rubella

DAYS ELAPSED	57
PEOPLE INFECTED	100
DEATHS	0

Mumps

DAYS ELAPSED	53
PEOPLE INFECTED	100
DEATHS	0

Chicken pox

DAYS ELAPSED	29
PEOPLE INFECTED	100
DEATHS	0

The Importance of This Model

If this model explains any aspect of earthquake phenomena, earthquake prediction becomes fundamentally impossible.

In other words, both small and large earthquakes start the same way.

An earthquake doesn't know at first whether it will grow larger or

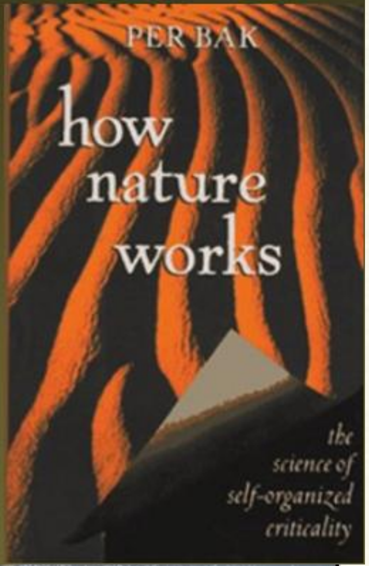
Deterministic or stochastic?

The future can be predicted by some equation.
-> Deterministic model

When a stochastic process is introduced in the system, predicting the future becomes difficult

Sand Pile Model (Per Bak.et,al.1987）

- Per Bak
  [1948-2002]



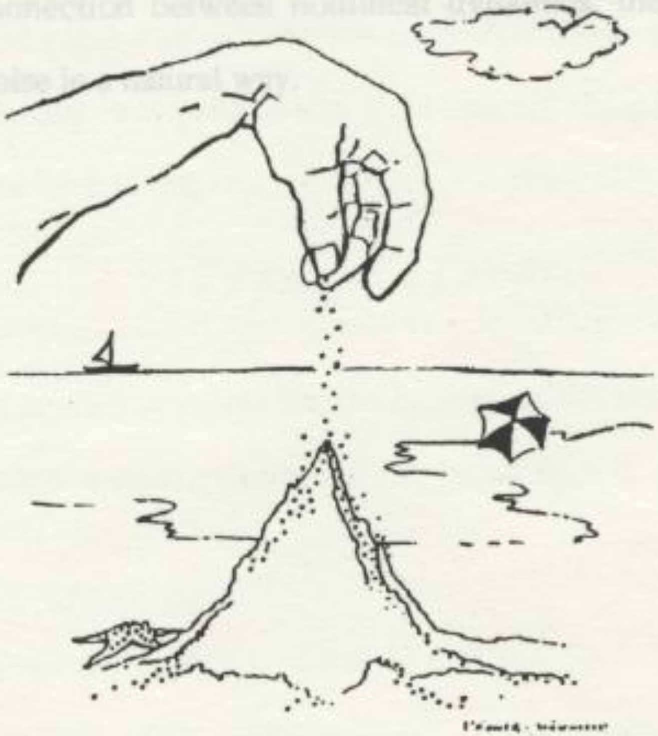


Figure 3.1.1 The formation of a sandpile (after *Bak et al.* [1988]). The pile reaches its critical state, in which the slope of the pile will grow no further.

Sand Pile Model (My Analog Experiment, 2014)

The inner rule is completely deterministic!

$$z(x,y) \rightarrow z(x,y) - 4,$$

$$z(x \pm 1,y) \rightarrow z(x \pm 1,y) + 1,$$

$$z(x,y \pm 1) \rightarrow z(x,y \pm 1) + 1,$$

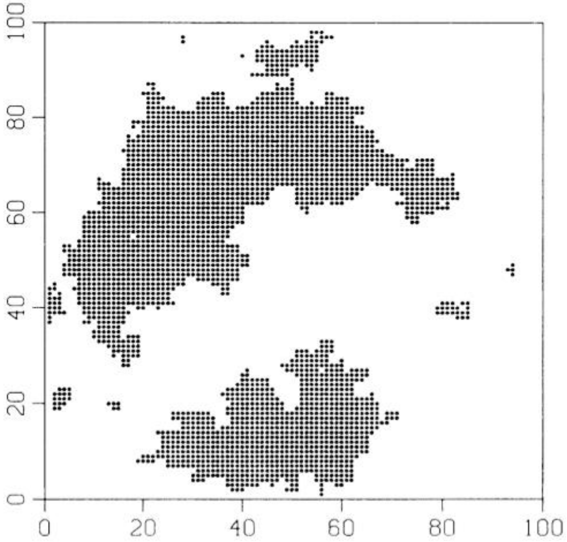


FIG. 1. Self-organized critical state of minimally stable clusters, for a 100×100 array.

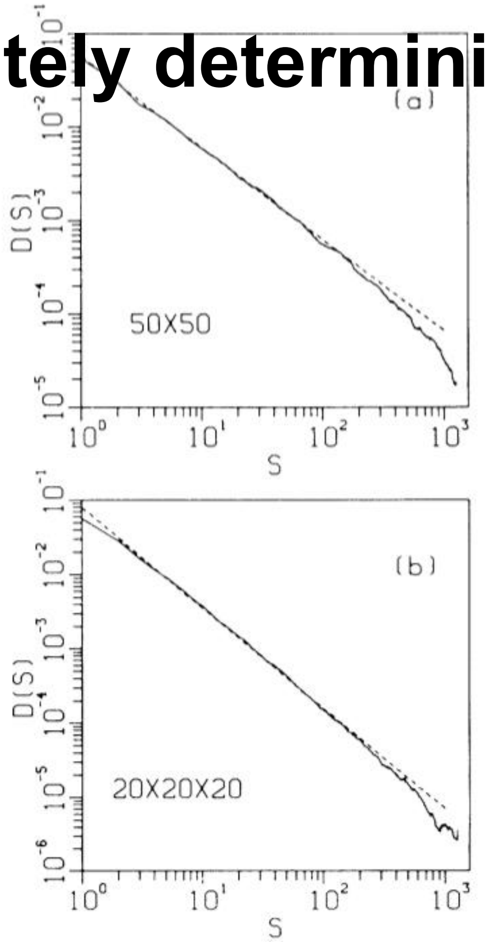
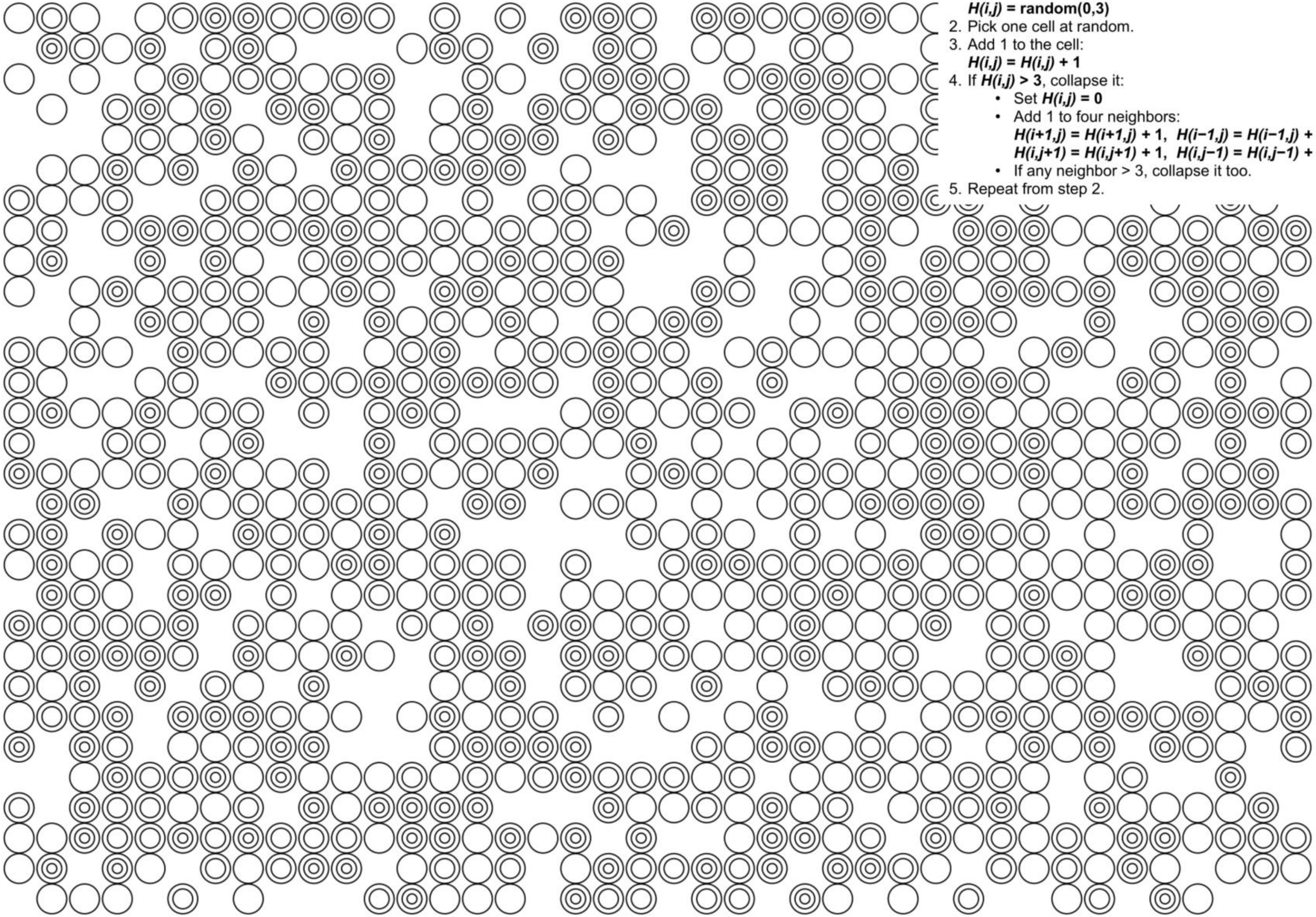
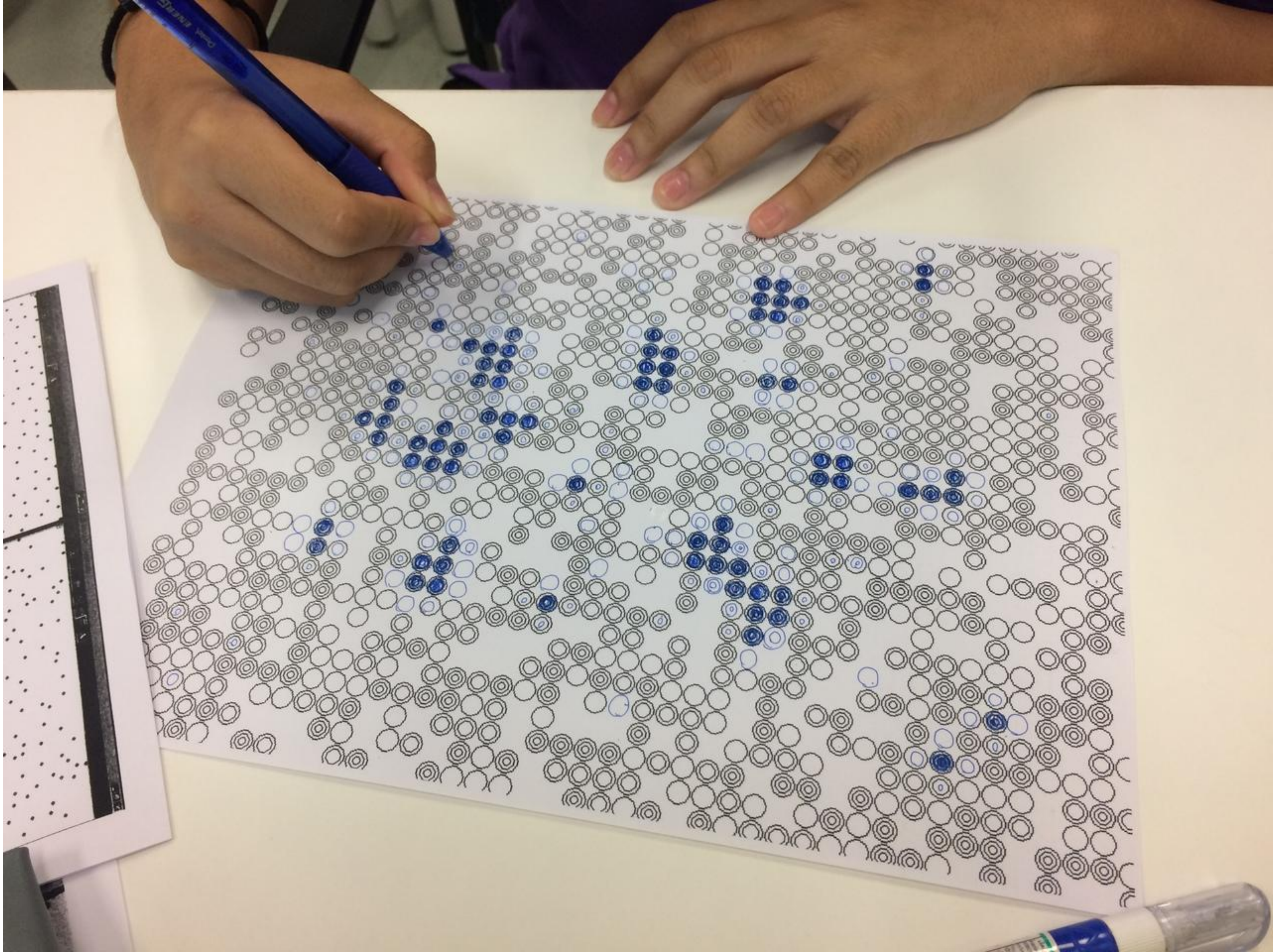


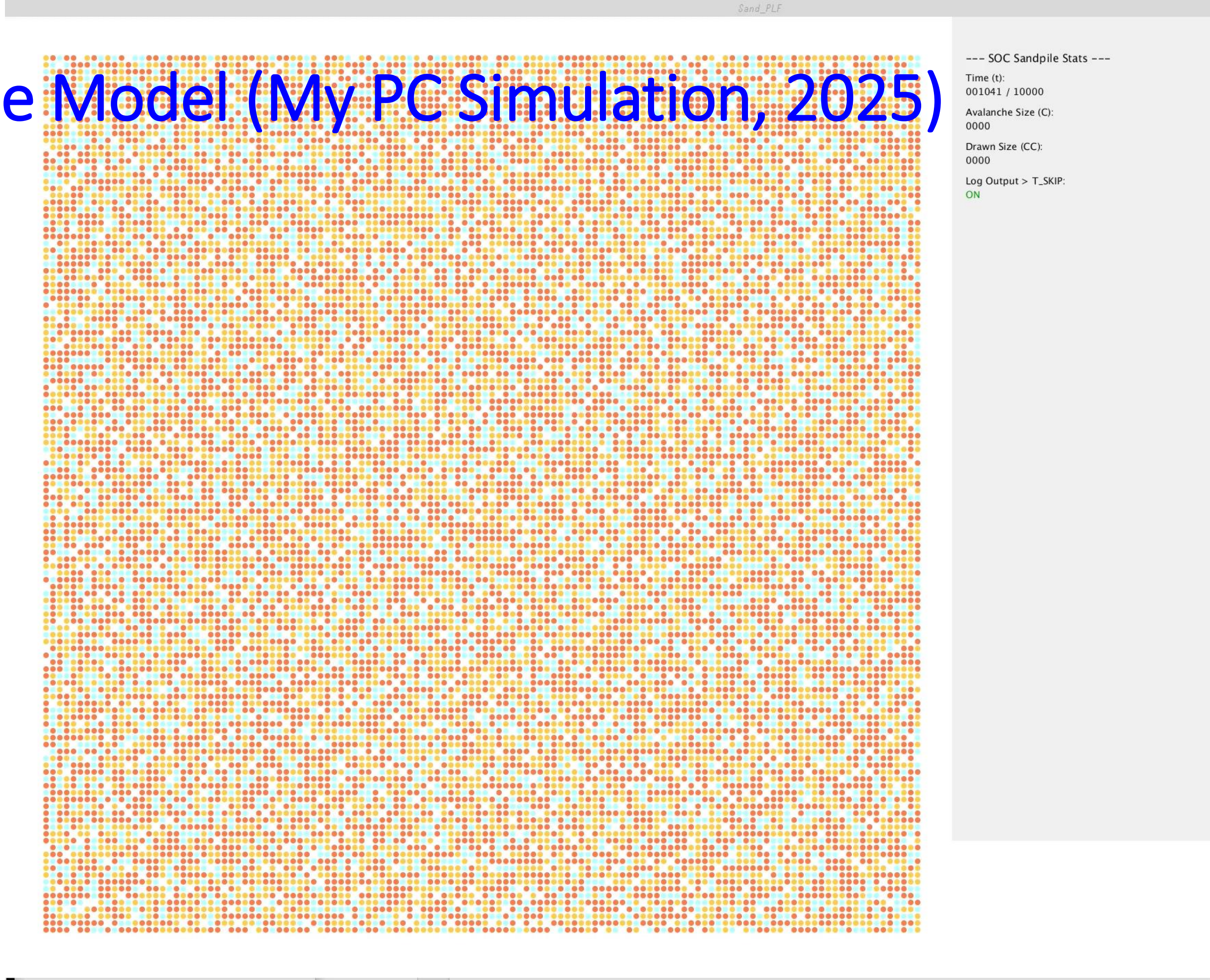
FIG. 2. Distribution of cluster sizes at criticality in two and three dimensions, computed dynamically as described in the text. (a) 50×50 array, averaged over 200 samples; (b) $20 \times 20 \times 20$ array, averaged over 200 samples. The data have been coarse grained.



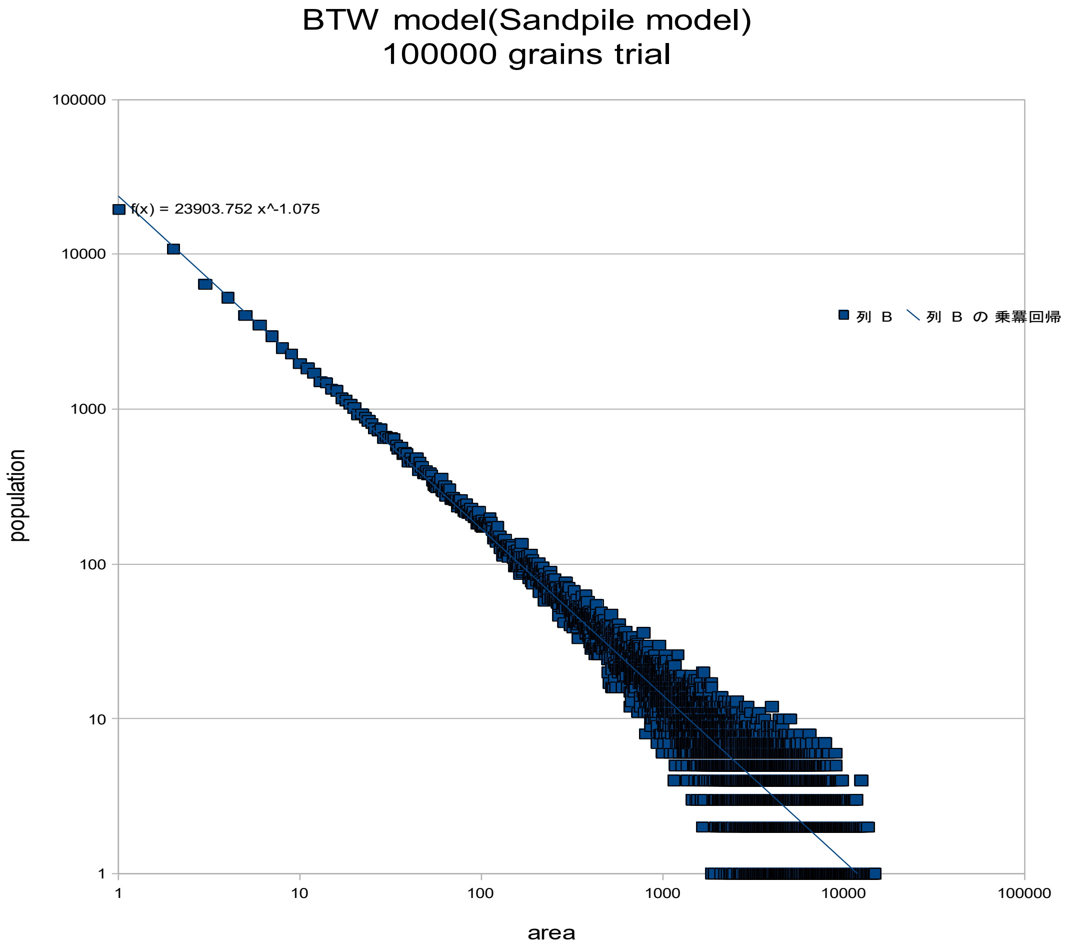
1. Set each cell to a random value 0–3:
   $\boldsymbol{H(i,j)}$ **= random(0,3)**
2. Pick one cell at random.
3. Add 1 to the cell:
   $\boldsymbol{H(i,j) = H(i,j) + 1}$
4. If $\boldsymbol{H(i,j) > 3}$, collapse it:
   - Set $\boldsymbol{H(i,j) = 0}$
   - Add 1 to four neighbors:
     $\boldsymbol{H(i+1,j) = H(i+1,j) + 1}$, $\boldsymbol{H(i-1,j) = H(i-1,j) + 1}$,
     $\boldsymbol{H(i,j+1) = H(i,j+1) + 1}$, $\boldsymbol{H(i,j-1) = H(i,j-1) + 1}$
   - If any neighbor > 3, collapse it too.
5. Repeat from step 2.



Sand Pile Model (My PC Simulation, 2025)

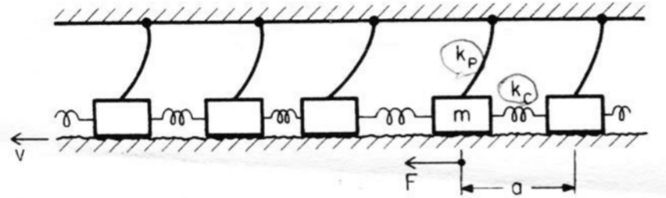


PC simulation (Sand Pile Model, Bak et.al.,1987)



Q_3: How do faults affect each other

- Even a simple model shows a little bit complicated pattern.
- If many faults affect each-other, what kind of thing happens??

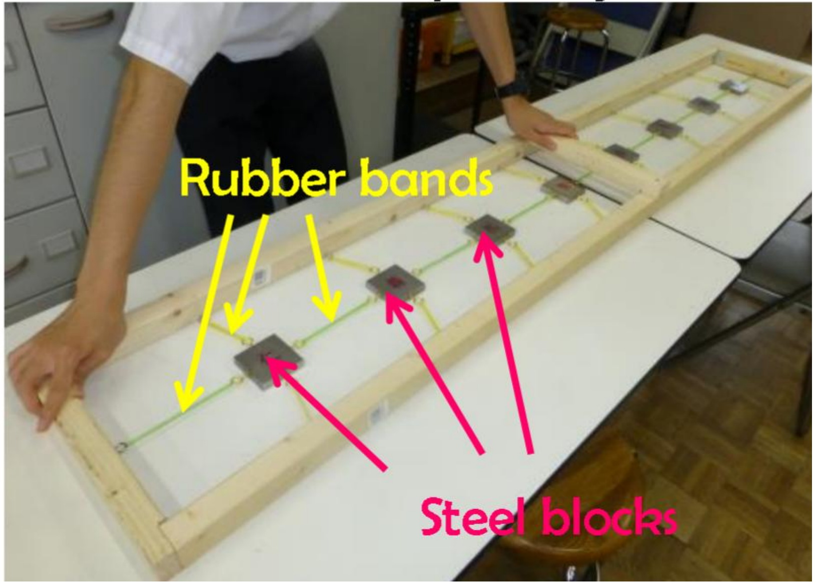


Burridge and Knopoff(1967) : Model and theoretical seismicity, BSSA.57, 341–371

Spring-block model

- What happens in a multi-block model?
- Theses models are originated by Burridge and Knopoff(1967), This S-B model is inspired by Kato(2011)

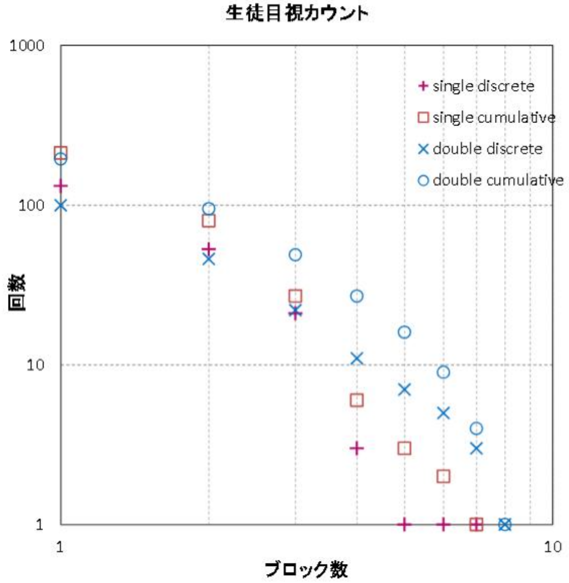
Spring-block model: 8 thick iron plates lined up in a straight are connected to a surrounding wooden frame with rubber bands. The frame is driven by hand.

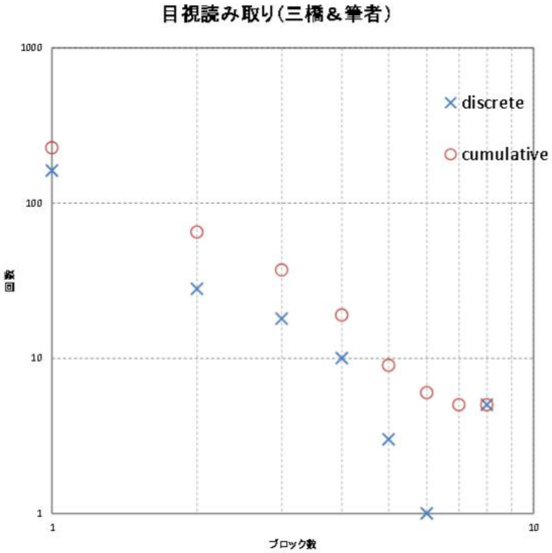


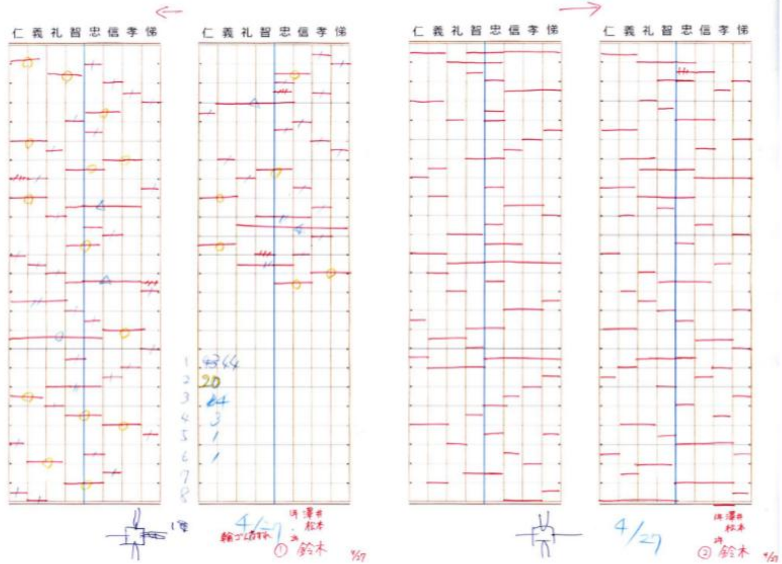
上左：旧モデル
下左：新，旧比較
上右：新モデルによる
　目視カウントの様子
下右：各種材料の変遷

ト例

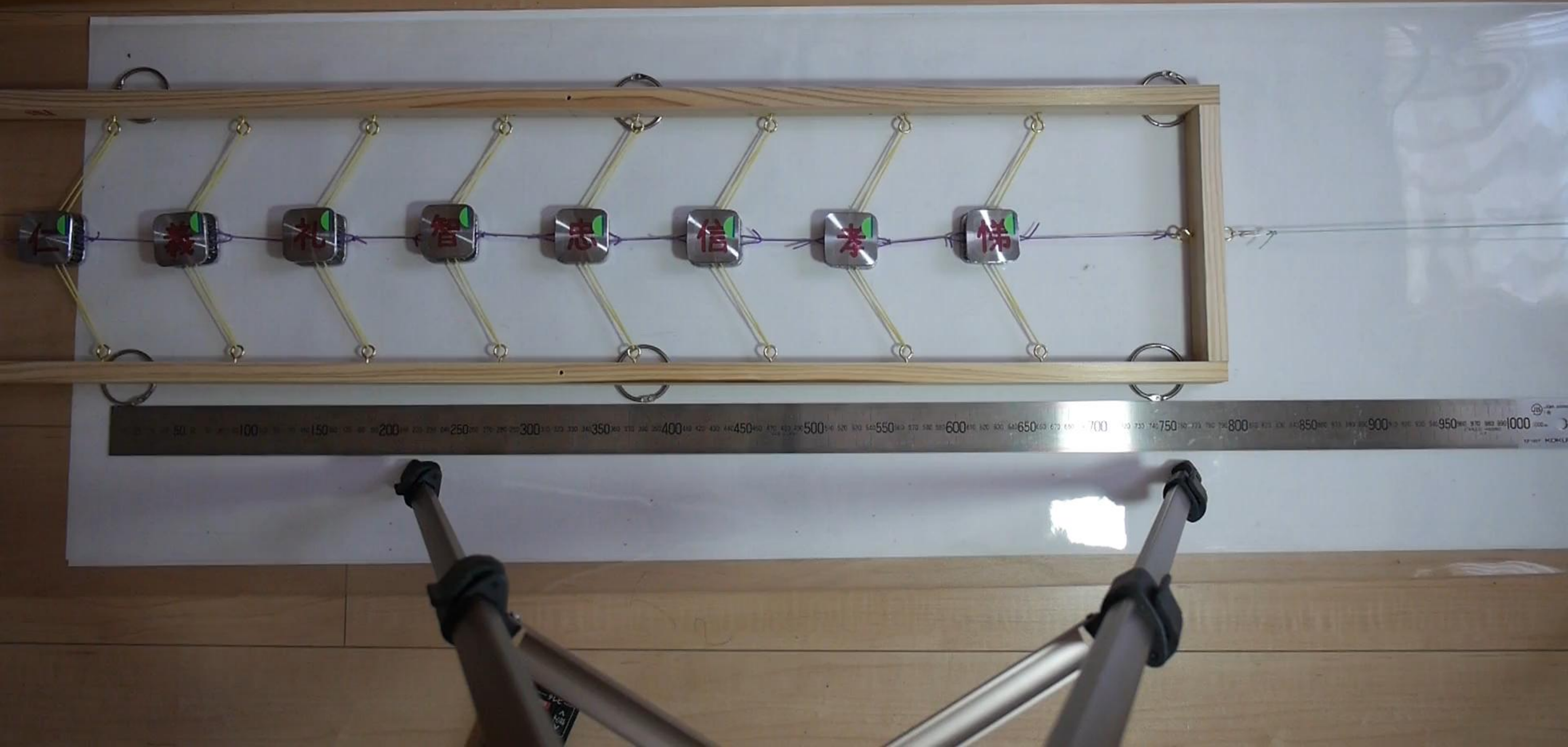
・高校生の例（G-R則は知らない）　・大学生＋筆者（G-R則は認識，剣山30mm）　・記録用紙例（高校生）

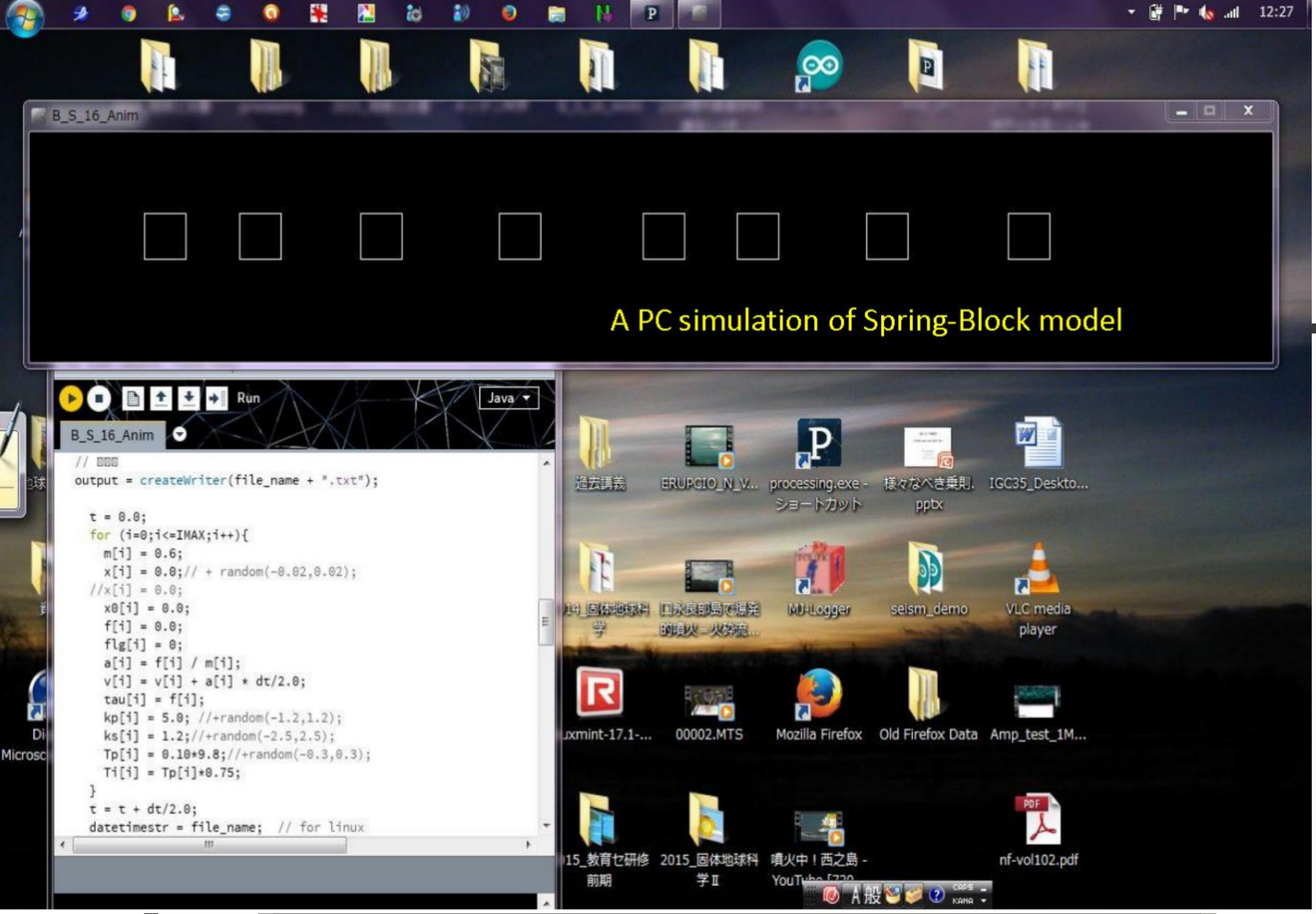




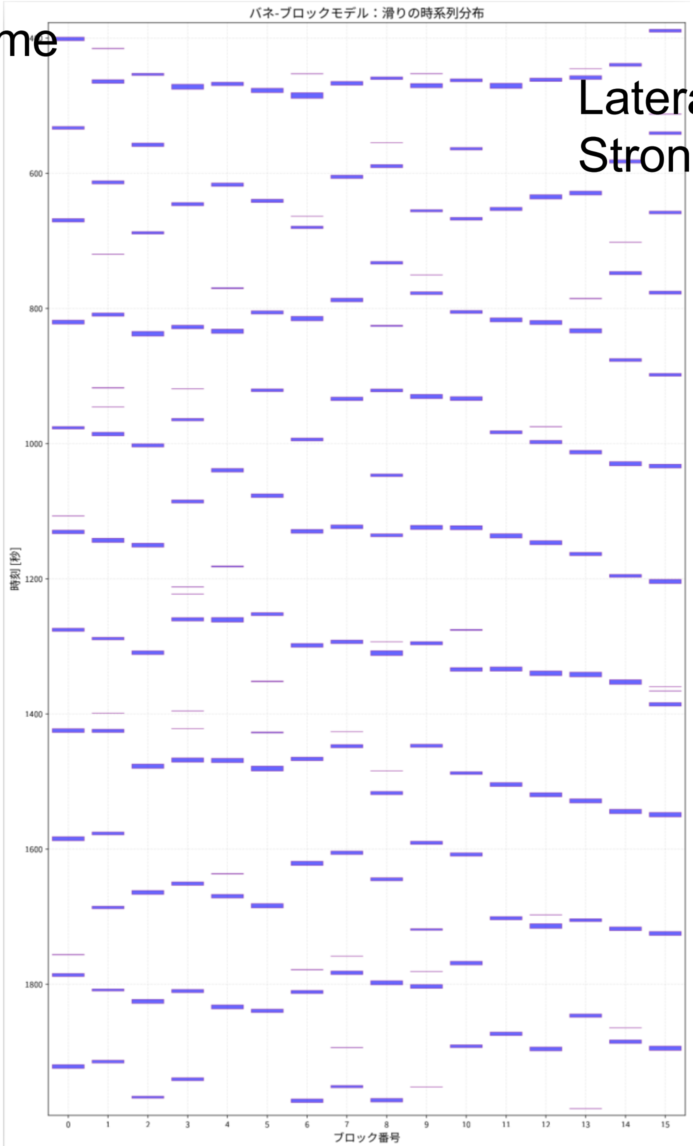


Spring-Block Model Y.Okamoto(2018)

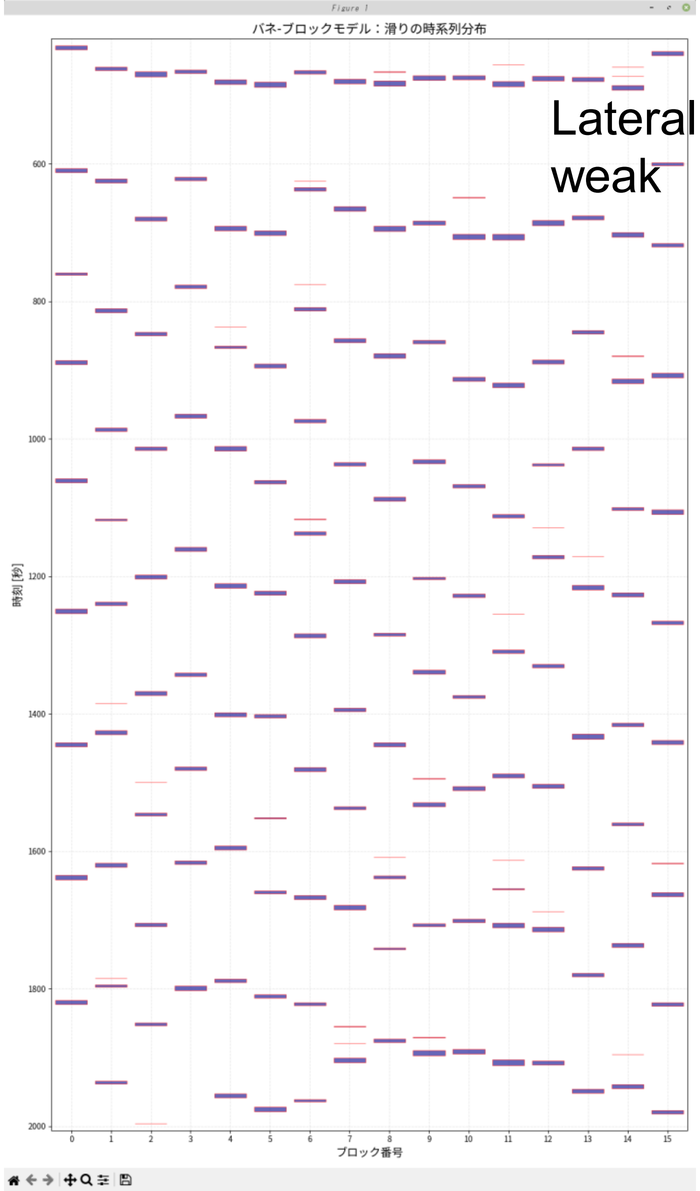



B_S_16_Anim
A PC simulation of Spring-Block model
Run
Java
output = createWriter(file_name + ".txt");
t = 0.0;
for (i=0;i<=IMAX;i++){
m[i] = 0.6;
x[i] = 0.0;// + random(-0.02,0.02);
//x[i] = 0.0;
x0[i] = 0.0;
f[i] = 0.0;
flg[i] = 0;
a[i] = f[i] / m[i];
v[i] = v[i] + a[i] * dt/2.0;
tau[i] = f[i];
kp[i] = 5.0; //+random(-1.2,1.2);
ks[i] = 1.2;//+random(-2.5,2.5);
Tp[i] = 0.10*9.8;//+random(-0.3,0.3);
Ti[i] = Tp[i]*0.75;
}
t = t + dt/2.0;
datetimestr = file_name; // for linux

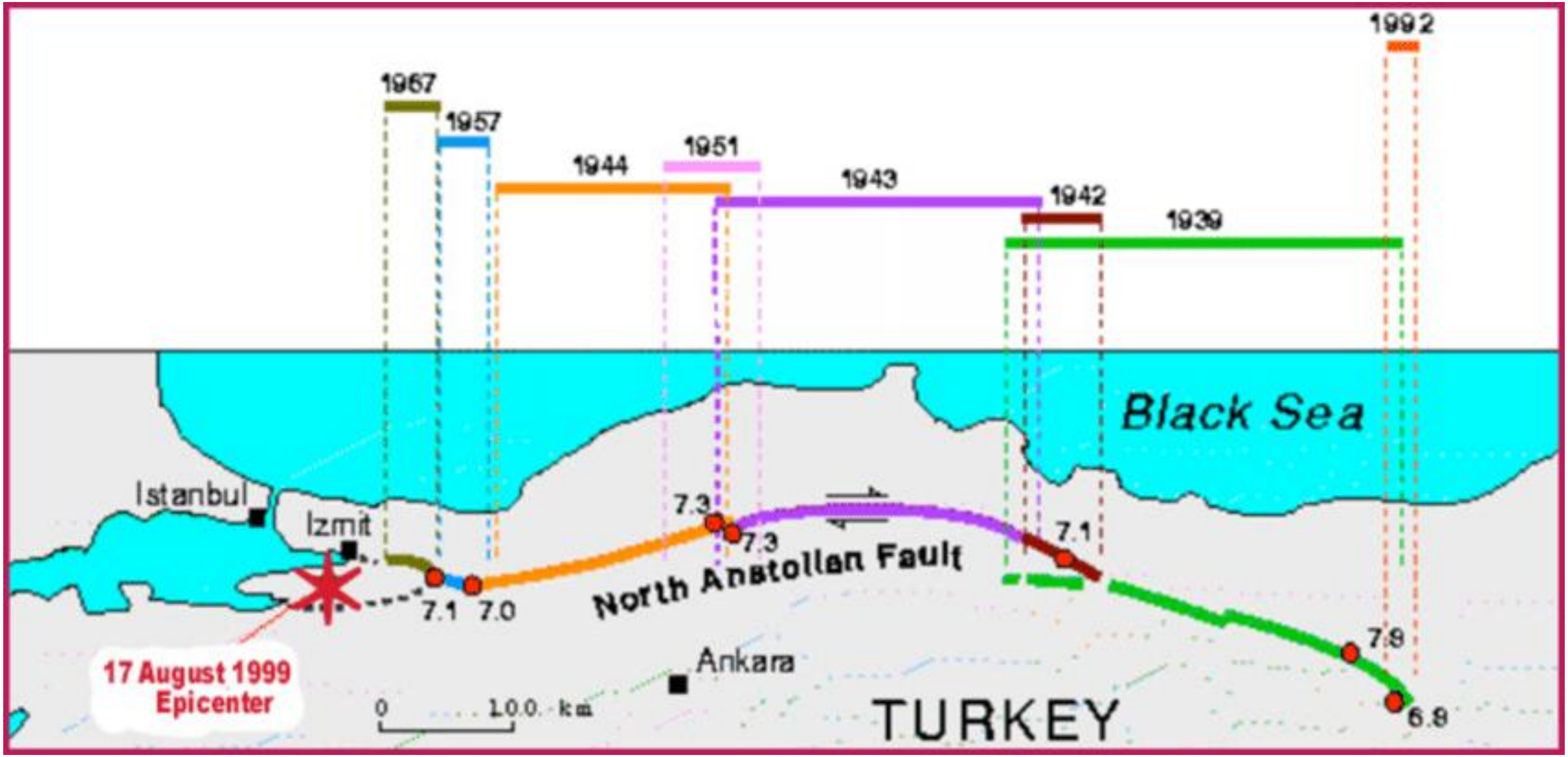
Time



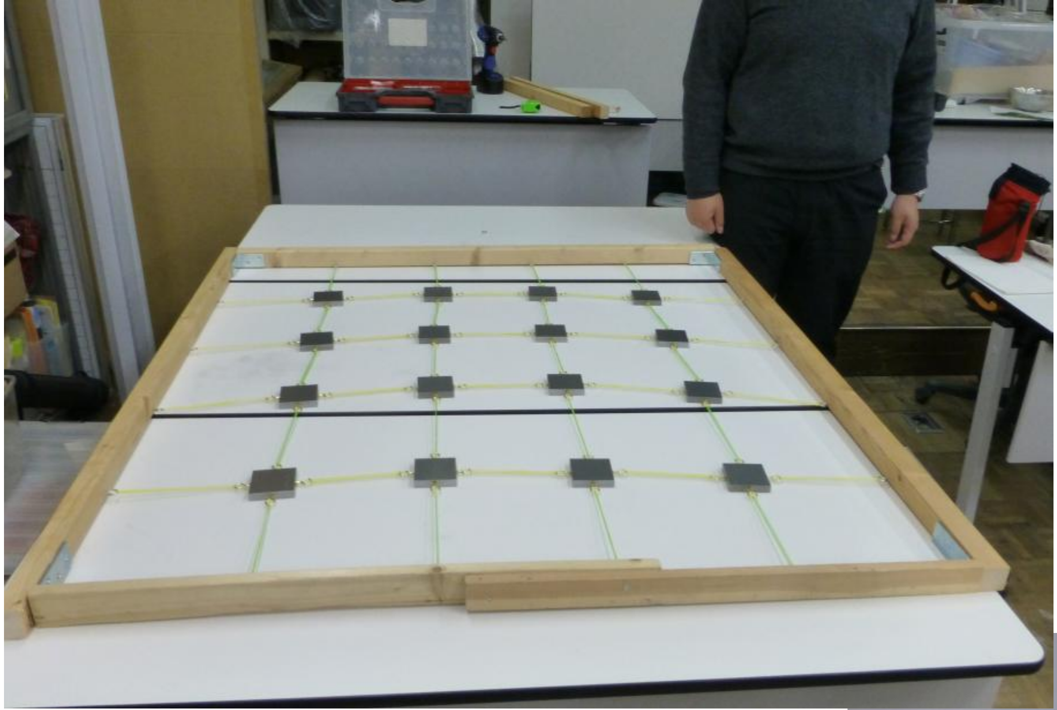
Lateral connection
Strong



Lateral connection
weak

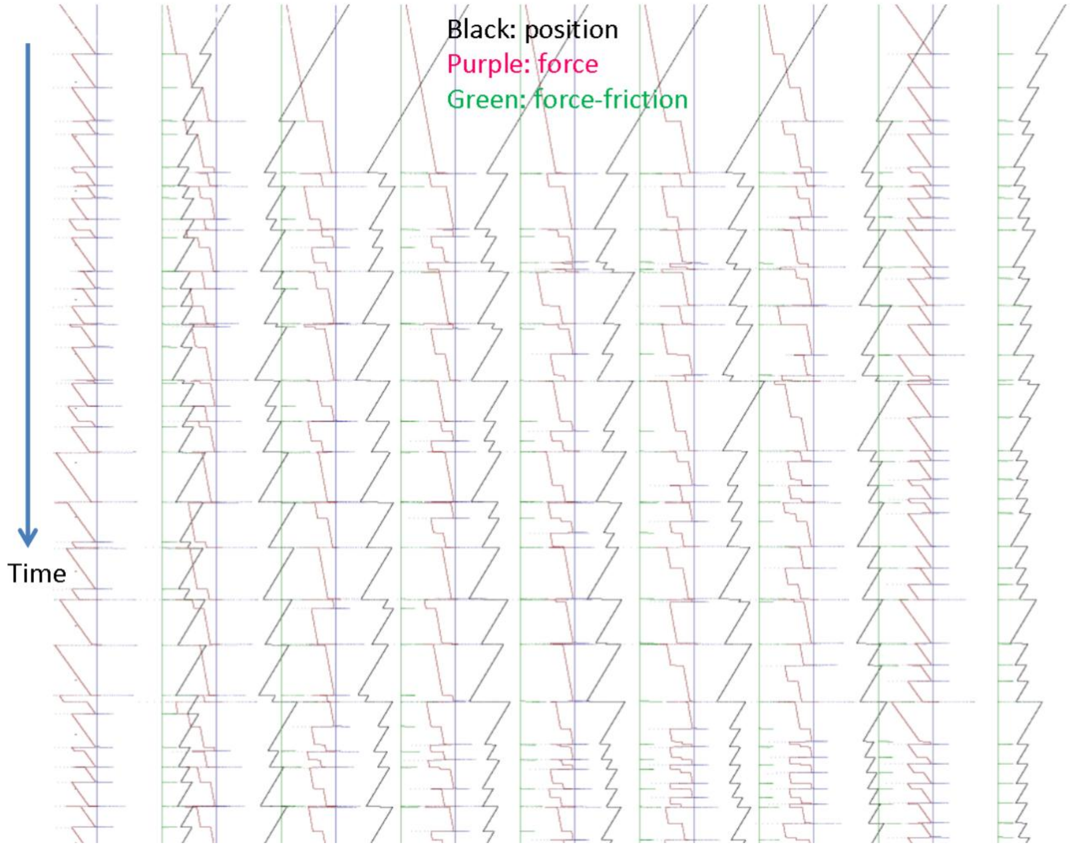


Historical Earthquake Activity Along the Northern Anatolian Fault (modified after Kandilli) Science of Tsunami Hazards, Vol. 30, No. 1, page 69 (2011)

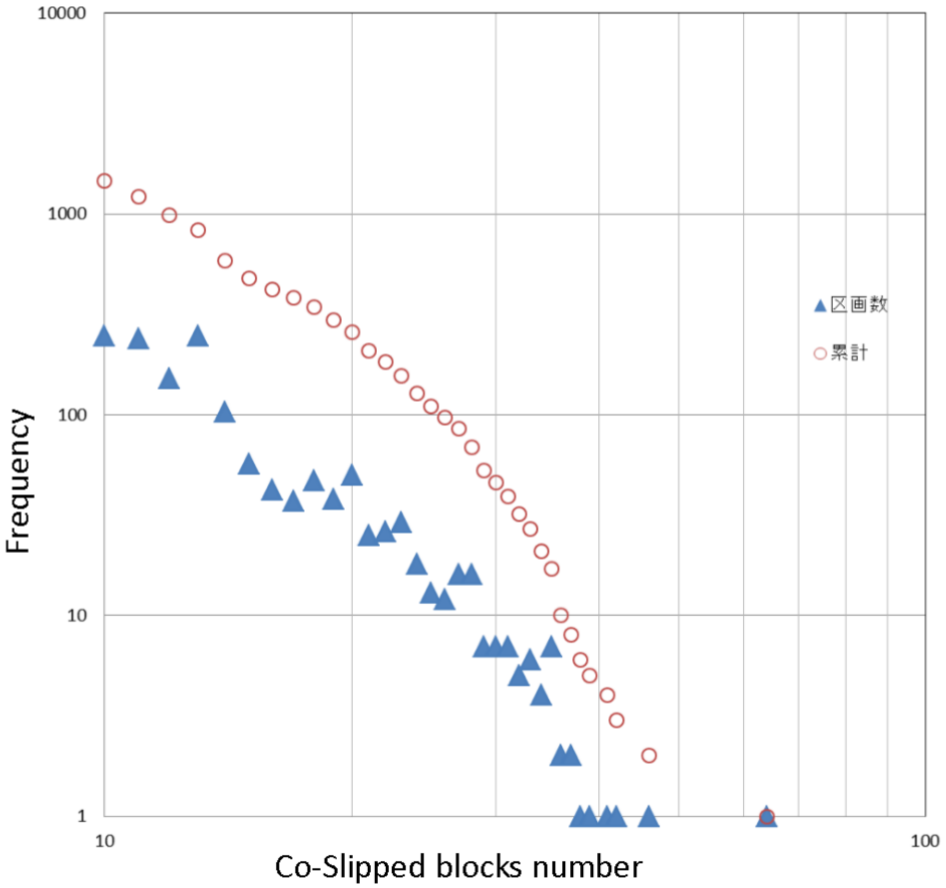


2次元モデル（2015年地球惑星連合大会，幕張での発表より）

本モデルにも用いた鉄ブロック



PC simulation results



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