

Japanese-Swiss Science and Technology Programme

Young Researchers Exchange Programme between Japan and Switzerland Scientific & Financial Report

Project No.	EG 09-2014
Project title	Young Researchers Exchange Programme between Japan and Switzerland 2014
Fellowship period	1.01.2015 – 30.06.2015
Swiss Principal Investigator / Host	Prof. Dr. Stefan Wiemer, Swiss Seismological Service, ETH Zurich
Japanese Fellow	Dr. Yusuke MUKUHIRA

1. Summary of scientific achievements (max ½ page; incl. pictures, suitable for publication)

Dr. Yusuke Mukuhira, Japanese fellow and Prof. Stefan Wiemer, Swiss Principal Investigator conducted statistical analysis of aftershock sequence at Basel EGS project to understand the statistical characteristics of aftershock. This can contribute much on seismic risk assessment at the hydraulic stimulation. We used Omori-Utsu law which is well known seismostatistical model to describe the aftershock decay process of natural seismicity. We successfully were able to model aftershock sequence at Basel. Estimated parameter in Omori-Utsu law explained the physical phenomena. We also analyzed aftershock with R&J model. Our estimates of time series change of b-value showed significant decrease before the occurrence of the largest event of $M_L 3.4$. But R&J model showed the probability of occurrence of events with $M_L > 3.0$ were around 0.1, suggesting that it was quite difficult to forecast the largest event at Basel and neither the event with $M_L > 3.0$ occurred after one month of the stimulation.

2. Scientific project achievements (max 2 pages)

Objective :

Understanding of aftershock behavior at the hydraulic stimulation is crucial for seismic risk assessment at hydraulic stimulation of EGS project. We conducted statistical analysis for Basel aftershock sequence which includes the large after shock of M3 one month after the stimulation. We tried to find the statistical characteristics for better understanding of the physics.

Result

1st working hypothesis:

Does the aftershock sequence continue? Or when is it over/was it over? Based on Omori-Utsu law.

- Whole aftershock sequence was fitted with Omori-Utsu law and parameters of Omori-Utsu law were estimated. Whole aftershock sequence at Basel can be modeled by single Omori-Utsu law, though the observed data deviated from model. (Fig. 1)
- We divided aftershock sequence into 3 terms (three branches) according to the deviation from the Omori-Utsu model for whole sequence. We estimated Omori-Utsu parameters for each branches. We had smaller AIC when aftershock sequence was divided into three terms than that of single Omori-Utsu law. We had very good fit for each branches. (Fig. 2)
- Aftershock sequence at Basel can be modeled by three branch which has different series parameters, which there should be different mechanism to trigger the aftershock.
- Duration of third branch was 8983.5 days (24.6 years). This suggested that the seismic activity still lasted more 15 years. (Fig. 2)

2nd working hypothesis:

Could the large events $M > 3.0$ in the aftershock sequence be expected?

- We used the Resenberg & Jones model (combination of Omori-Utsu and GR law). We used the b-value and Omori-Utsu parameters estimated from 1) whole aftershock sequence, 2) every 0.1 day or every 1 day in 0.1-1 day period and 1-10000 day period respectively.
- Using these parameters, we estimated occurrence rate/probability of the events $M > 3.0$ in next one day and the occurrence time/probability were compared with the observation of the events with $M > 3.0$.
- For constant b-value and Omori-Utsu parameters, we had high probability/occurrence rate, ex. 0.55 of probability at 0.1 day from the stimulation. But it decreased exponentially with the elapsed time.
- From the time series change of b-value, it started around 1.5 and started to decrease since 0.3 day. The largest event occurred around 0.7 day. So b-value decreased before the occurrence of the largest event.
- The probability of the events $M > 3$ at 0.1 day were relatively high, being more than 0.2.
- Probability/occurrence rate stayed same level from 0.1~1 day more than 0.01 and then decreased lineally in logarithm to 10 days.

Conclusions

- Aftershock sequence at Basel can be modeled by three branched model rather than single Omori-Utsu law. For each three branched periods, decay rates of the aftershock are also different, suggesting that the responsible parameter/mechanism to trigger the induced seismicity are also different too.
- According to the Omori-Utsu law, the duration of third branch was 8983.5 days and aftershock sequence lasts more 24.6 years.
- The probability of the large event with $M > 3.0$ at 0.1 day after shut-in was 0.1, suggesting that we cannot say that large events were not expectable. The probability of the other event with $M > 3.0$ is less than 0.0001. Therefore, we can conclude that this event can not be expected from the point of view of seismostatistics. However, at that period, the probability is slightly increasing.

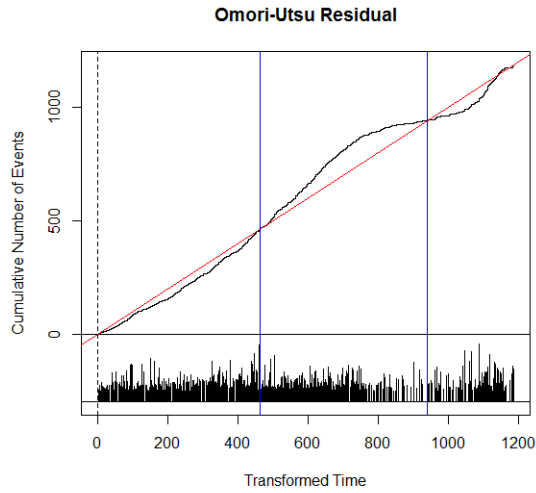


Fig. 1: Virtual fitting of Omori-Utsu law for whole aftershock sequence

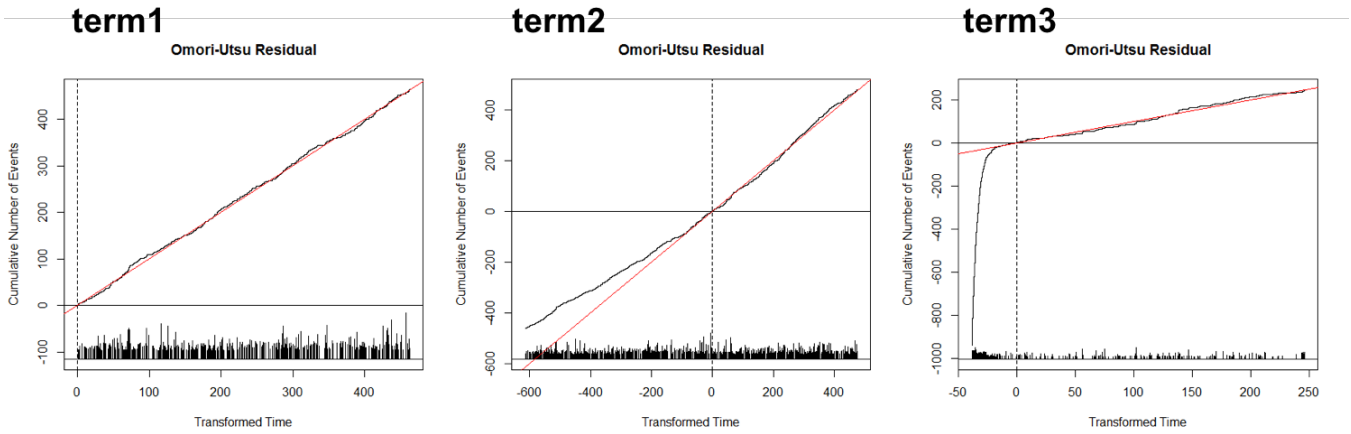


Fig. 2: Visual fitting of Omori-Utsu law for three branch

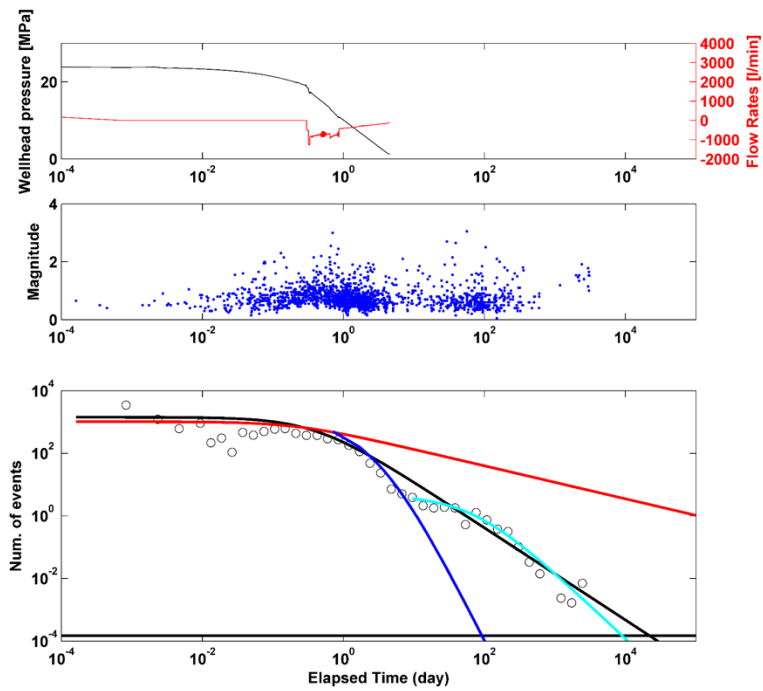


Fig. 3 Duration time estimated from three branch model

3. Partnership

- Is the exchange based on an existing partnership between the Japanese and Swiss research groups?
Our research group in Japan was in good relationship with ETH scientists of previous generation working for geothermal development. So I contacted one of them, then they introduced me my host scientist. But now, we don't have official corroboration and we are somehow a competitive relationship with Swiss research groups, but not negative rival. Sometimes, we shared the information on research and insights. For myself, individually I have been keeping very good relationship with young scientists and Ph.D student in ETH since when I stayed ETH three weeks when I was Ph.D student.
- Did the cooperation between fellow and host go well?
Honestly, I feel that it did not go well at all. I could not conduct the research which I planed to do in proposal. Host scientist gave me only couple of time to have a discussion. He always ignored my email to ask appointment and cancelled discussion with me suddenly. Finally, he rejected my offer to publish the result of study at ETH after I came back to Japan since the quality of the data they provided me in March was not enough to do something scientifically. He never explained how the data is not good. My scientific adviser (different person of host scientist) did not think that the quality of the data is bad and he agreed to publish our result.
- Will there be a continued collaboration after the return home of the Japanese fellow?
I offered further collaboration study after I came back to Japan. But my host scientist never replied my email as usual. Therefore, I originally offered collaboration study with my scientific adviser at ETH, which he is very kind and fair person.

4. Please describe how the Swiss host and Japanese fellow have benefited from this exchange

From my side, I could learn new scientific perspective. Before this program, I conducted my research with deterministic way. But I did statistical analysis at ETH even though I don't want to do that. Due to the help of my research adviser, I found very interested in the statistics which is the different way to look at natural phenomena. I feel that I could develop my skill and scientific view.

From the side of Swiss host scientist, I really don't know what they got. But I had to leave analysis code which I originally made due to agreement. Maybe it can help them to conduct statistical analysis on aftershock sequence of hydraulic stimulation.

5. Outlook

Nothing.

6. List of Publications

No publication is expected because my host scientist rejected my offer to publish paper.

7. Miscellaneous

- Do you expect any patents coming out of this project?
No. Our research is pure geoscience. No patents can be expected.
- Do the results of this project have commercial potential? Do you think there could be an industrial partner involved in this project in the next phase?
No. Our research is pure geoscience. No patents can be expected.

8. Suggestions for the next phase of the exchange programme

I really recommend to join the group which is good relationship with fellow and he/her supervisor. It is also important to evaluate our exchange program fairly by third party. For the guest scientist, fellow having

their salary can be free human resource. In my case it worked in not good way. I was not important to them. But this kind of things should not be good things for everyone.

But my experience was not meaningless at all. We, Japanese scientist sill has low evaluation in terms of communication skill, working style and less assertive and sometimes we might suffer discrimination. If we survive global academia, these are the challenge we have to overcome.

9. Financial report

- Please include a copy of the account report from your financial department concerning this project. Original receipts need not accompany this financial report. However, please keep the original receipts for 5 years after the project has finished.

I attached the financial reports which was provided by the person in charge financial matter in group I joined.

10. Appendix (please attach any additional documentation such as pictures or links to media coverage)

Zürich, 06.08.2015

Fondsauszug

Buchungszeitraum

Buchungsjahr

Januar bis August 2015

01.01.2015 bis 31.08.2015

2015

Ihr Fonds auf einen Blick

Fondsnummer	2-71278-14	EG 09-2014_Mukuhira
Finanzstelle	02818	Schweiz. Erdbebendienst (SED)
Bereich	T0022	T-Bereich VP Forschung & Wirtschaftsbez.
Budgetverantwortliche/r	Stefan Wiemer	
Stv. Budgetverantwortliche/r	Florian Haslinger	
Fondsinhaber/in		
Administrator/in 1	Sabine Brühwiler	
Administrator/in 2	Elisabeth Läderach	

Gutschriften und Belastungen im Buchungszeitraum**CHF**

Saldo per 01.01.2015 zu Ihren Gunsten	0.00
Total der Gutschriften	13,212.55
Total der Belastungen	14,099.72
Saldo per 31.08.2015 zu Ihren Lasten	887.17

Wir bitten Sie, die beiliegenden Dokumente zu prüfen. Diese gelten als richtig anerkannt, sofern uns Beanstandungen nicht innerhalb Monatsfrist mitgeteilt werden (vgl. Art. 59 Abs. 3 Finanzreglement).

Bei Fragen steht Ihnen gerne Ihr/e Kundenberater/in, Herr Pasquale Nigro, per Telefon unter +41 44 632 55 73 oder E-Mail pasquale.nigro@fc.ethz.ch zur Verfügung.

Freundliche Grüsse
Abteilung Rechnungswesen

Fondsauszug Januar bis August 2015

Fondsnummer: 2-71278-14 **Buchungszeitraum:** 01.01.2015 bis 31.08.2015
Budgetverantwortliche/r: Stefan Wiemer **Buchungsjahr:** 2015 **Erstellungsdatum:** 06.08.2015

Beleg- nummer	Buchungs- datum	Beleg- datum	Kreditor/Debitor	Referenz / Buchungstext	Sach- konto	Ausgaben- bzw. Einnahmenart	Whrg	Betrag Fremdwhrg	Belastung in CHF	Gutschrift in CHF	Fondssaldo in CHF
Saldo per 01.01.2015 zu Ihren Gunsten											0.00
11003165	29.01.2015	19.01.2015		MITTEL Mittelverschiebung z.L 2-71058-13	782902	ZM-DMittel Transfer				13,212.55	13,212.55
21011198	02.02.2015	20.01.2015	Mukuhira Yusuke	REIMBURSEMENT	443001	Flugreisen		1,484.10	1,171.99		12,040.56
14xxxxxx	31.01.2015	31.01.2015		Löhne/Gehälter					2,133.35		9,907.21
14xxxxxx	28.02.2015	28.02.2015		Löhne/Gehälter					2,133.35		7,773.86
14xxxxxx	31.03.2015	31.03.2015		Löhne/Gehälter					2,133.35		5,640.51
14xxxxxx	30.04.2015	30.04.2015		Löhne/Gehälter					2,133.35		3,507.16
14xxxxxx	31.05.2015	31.05.2015		Löhne/Gehälter					2,133.35		1,373.81
14xxxxxx	30.06.2015	30.06.2015		Löhne/Gehälter					2,133.35		759.54-
21093425	27.07.2015	17.07.2015	Mukuhira Yusuke	REIMBURSEMENT	443001	Flugreisen		162.98	127.63		887.17-
Additionen									14,099.72	13,212.55	
Saldo per 31.08.2015 zu Ihren Lasten											887.17-