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School of Engineering

NGL: An Open-Source Database for Next-Generation of Liquefaction Assessment Procedures and its Impact on Global Community Resilience

Paolo Zimmaro, Ph.D.
Project *Scientist and Lecturer*

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NGL
NEXT GENERATION LIQUEFACTION

Engineer Change.

Outline

Introduction and project needs

The Next-Generation Liquefaction database

Current status of the NGL database

Vision for community access and final remarks

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NGL Database Contributors

- ***NGL leadership****: Jonathan Stewart, Steven Kramer, Yosef Bozorgnia*

- **Database working group**: Scott Brandenberg (chair), Robb E.S. Moss (Cal Poly), K. Onder Cetin (METU), Kevin Franke (BYU), Paolo Zimmaro (UCLA), and Dong Youp Kwak (Hanyang University)

- **Southwest Research Institute**: John Stamatakos, Miriam Juckett, Bis Dasgupta, Joey Mukherjee, Zackary Murphy, Steven Ybarra

- **Nuclear Regulatory Commission**: Thomas Weaver

- **Caltrans**: Tom Shantz

NGL Database Contributors

- ***U. of Utah:*** Steve Bartlett, Masoud Hosseinali

- ***Virginia Tech***: Russell Green, Kristin Ulmer

- ***UC Berkeley***: Jonathan Bray, Christine Beyzaei

- ***Tonkin & Taylor***: Sjoerd Van Ballegooey, Mike Liu

- ***BYU***: Heidi Dacayanan, Lila Lasson

- ***METU***: Gizem Can, Makbule Ilgac

- ***UCLA***: Omar Issa, Chris Nicas, Trini Inouye, Arielle Sanghvi, Tristan Buckreis, Naoto Inagaki, Wyatt Iwanaga, Michael Winders, Bryan Ong, Siddhant Jain, Allison Lee, Honor Fisher

- ***Others***: Mike Greenfield, Teruo Nakai, Hideo Sekiguchi, …

PEER Caltrans SwRI U.S.NRC MPC MOUNTAIN-PLAINS CONSORTIUM UDOT Keeping Utah Moving

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Current challenges: Liquefaction and its effects

Liquefaction manifestations (Loma Prieta, 1989)

From Bray (2013)

Effects on infrastructure (Northridge, 1994)

Northridge collection (EERC)
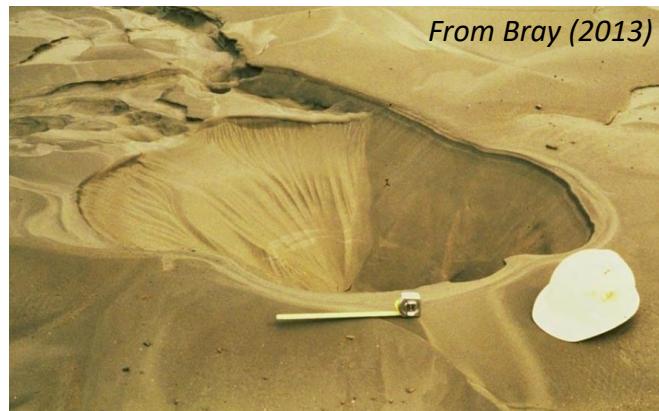
and its effects (Kocaeli, 1999)

From Bray (2013)

and distributed systems (levees, Tohoku, 2011)

(a)

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Current challenges: regional-scale analysis

Community resilience – The example of Christchurch
Post-earthquake damage assessment (2011 event)
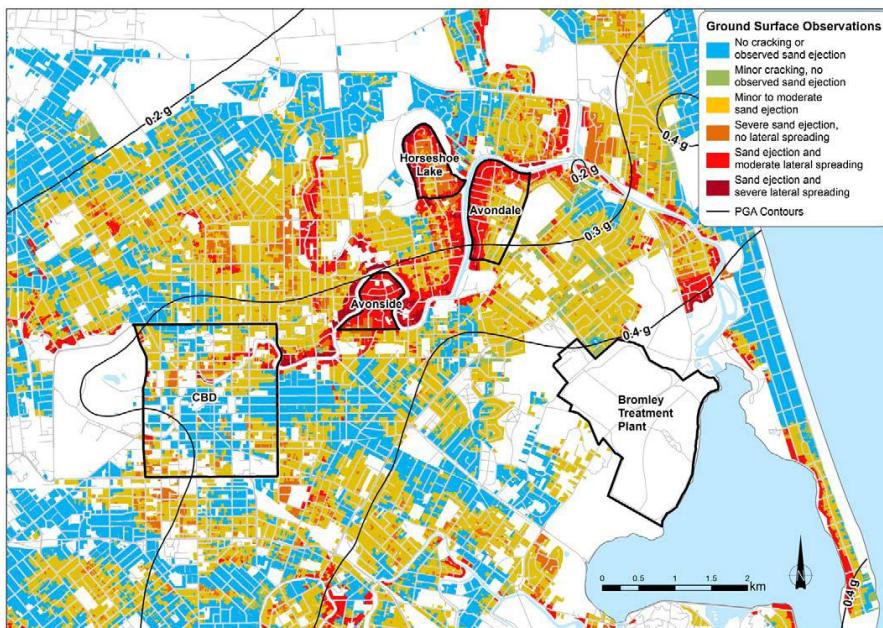
Liquefaction-induced damages
(from van Ballegooy et al., 2014)
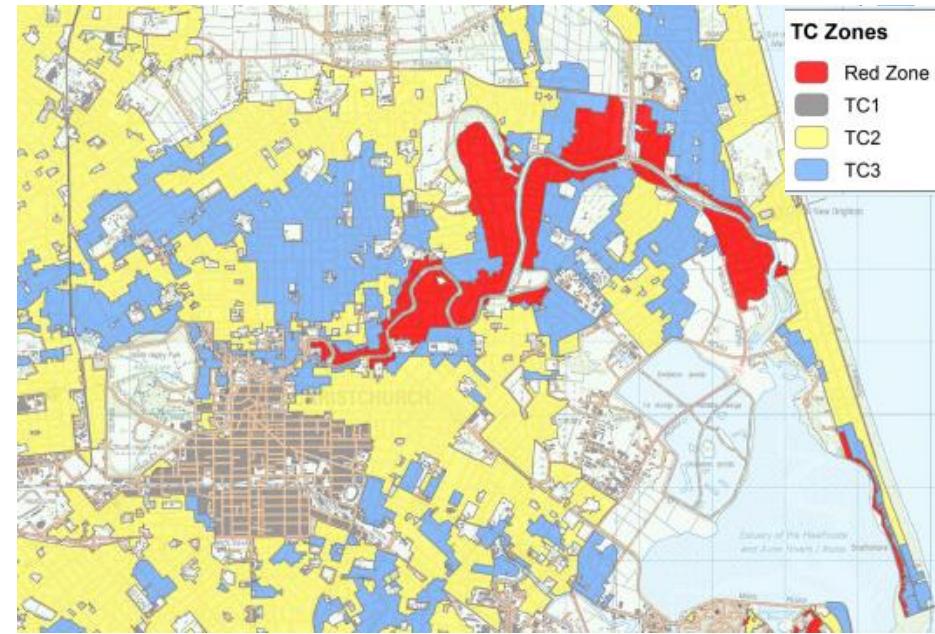
Future land planning of Christchurch
(from Saunders and Becker, 2015)

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Project needs

Liquefaction triggering assessment: current status

Small data sets

A **few sites** are especially consequential

Alternate liquefaction models provide **different outcomes**

Existing data sets are necessarily **incomplete**, especially:

Depth > 10 m

M > 7.5 and **M** < 6.0

FC > 30%

CSR > 0.4
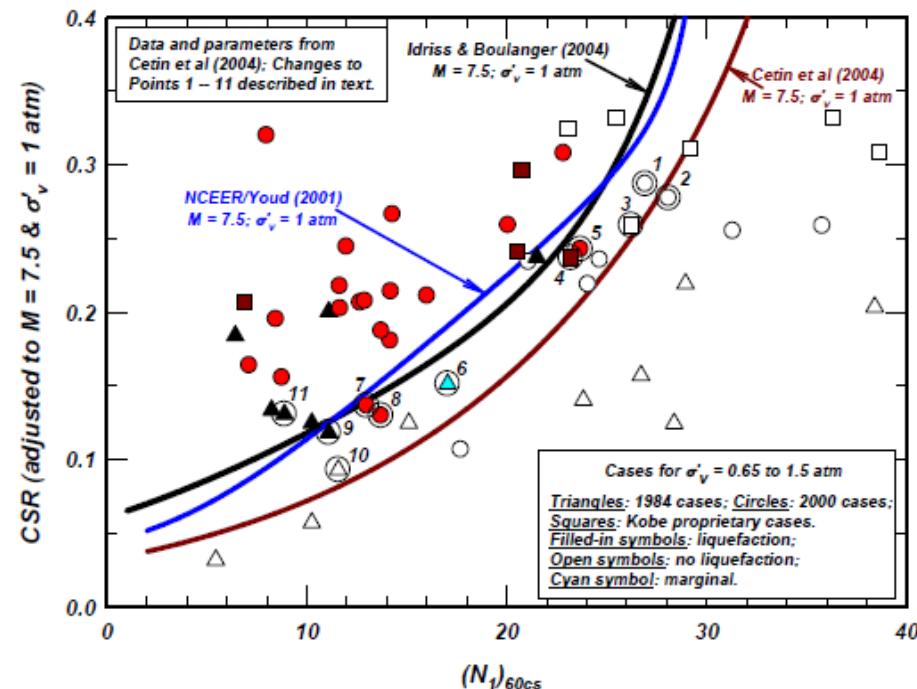
From Idriss and Boulanger (2010)

Data quality: Legacy vs new case-histories

Legacy case histories:

face clay silt layer.   Following the 1977 earthquake, signs of liquefaction such as ejection of fine sand through the fissures or cracks <u>were observed here and there in this</u> area.   Photo. 2 shows typical sand ejection

Earthquake	M_w
1977 Vrancea, Romania	7.20±0.11
Site	Liquefied?
Site 2	No

- Liquefaction
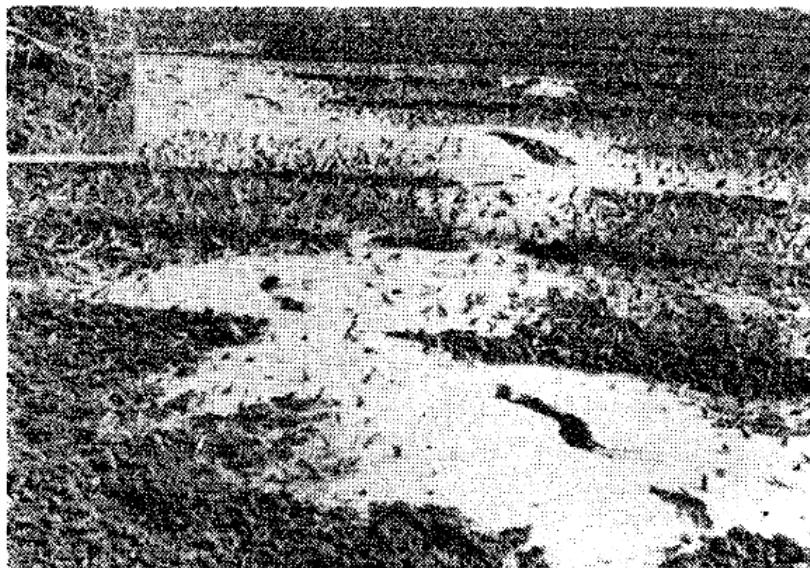
○ No Ground Failure

Bucarest (1977, Vrancea earthquake)
From Ishihara and Perlea (1984)
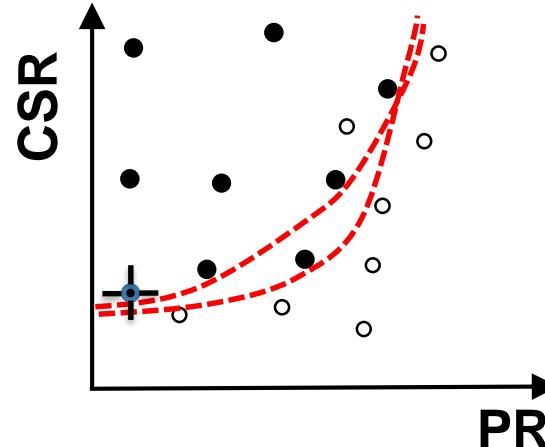
Data quality: Legacy vs new case-histories

Recent case histories:

- High-quality characterization
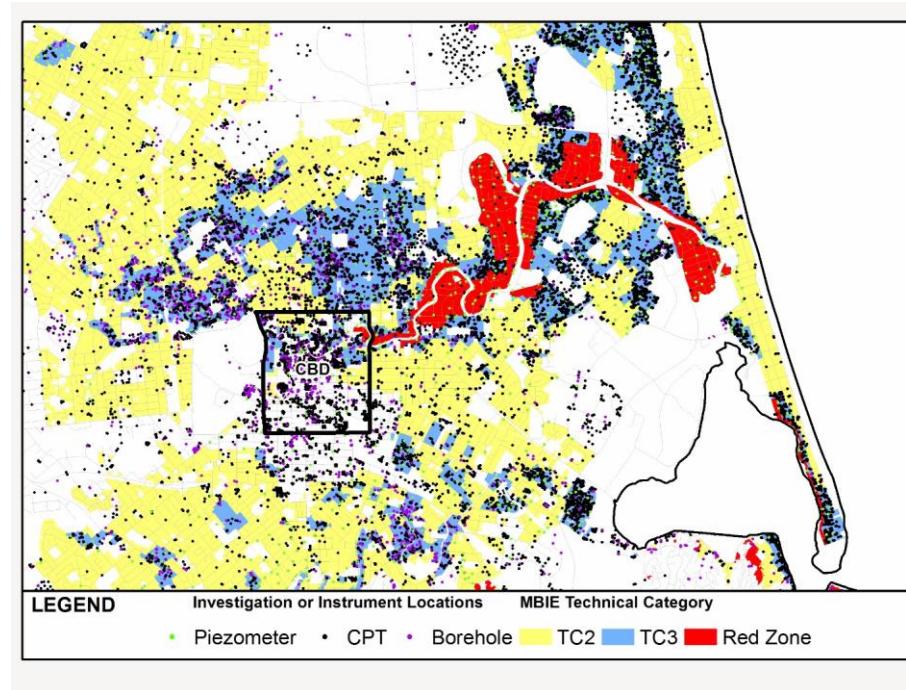
The Canterbury Geotechnical Database
From: www.tonkintaylor.co.nz

Data quality: Legacy vs new case-histories

Recent case histories:

- High quality magnitude estimation
- Large digital networks (good ground motion characterization)
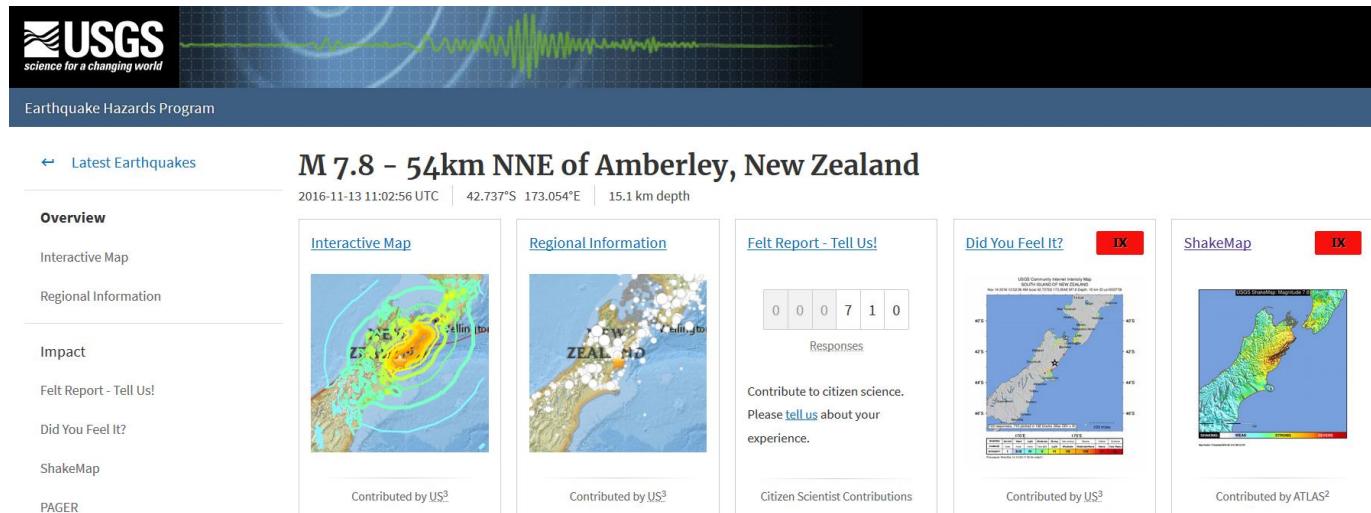
Event page for the 2016 Kaikoura earthquake (New Zealand)
From earthquake.usgs.gov

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Data quality: Legacy vs new case-histories

Recent case histories:

• Unprecedented quantity/quality of observations
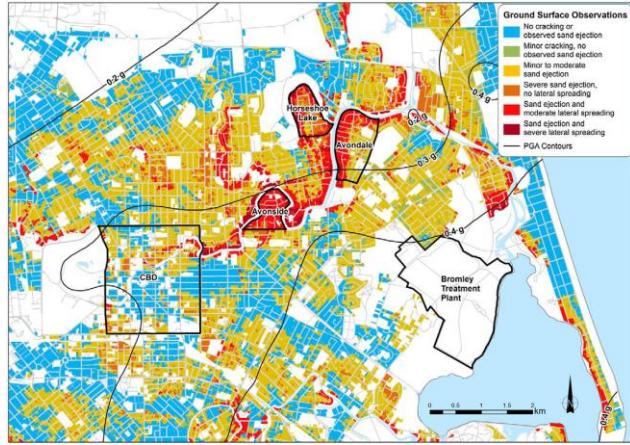
From Van Ballegooy et al. (2014)
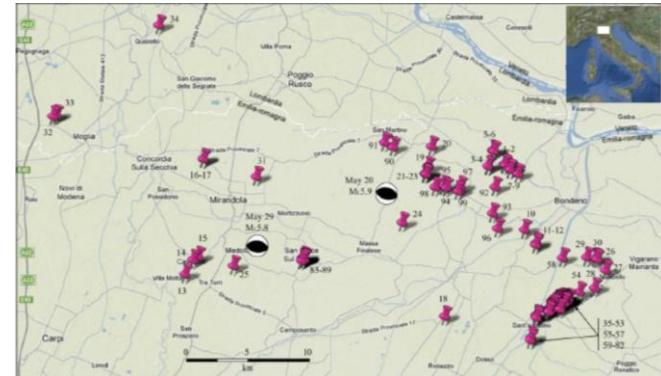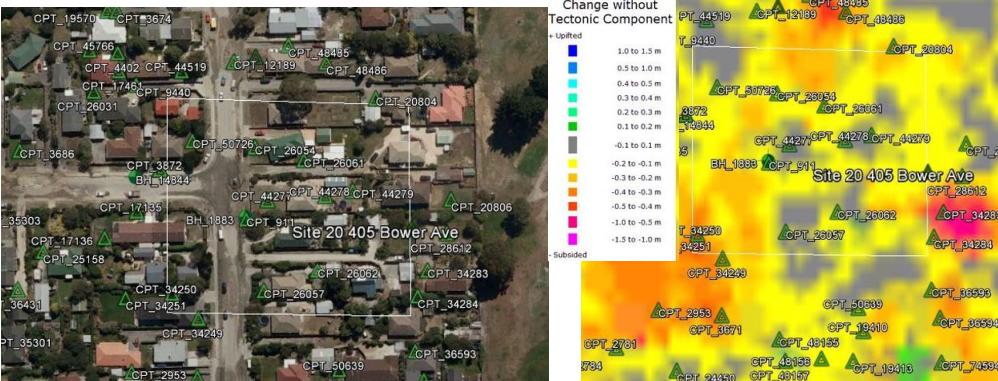
From Emergeo (2012)

NGL Vision

- Community field **case history database**

- **Fully-vetted** database

- **Formal relational database**

- Large amount of **high-quality** data

- **Supporting studies** of critical effects poorly constrained by data

- **Model development**: team meetings, common resources, required parameter space

Traditional vs Next-Generation Databases

From *spreadsheet*
(Traditional data analysis)

To **relational database**
(big-data analytics)

Next-Generation Liquefaction Database, Zimmaro et al. (2018a, SSA), Brandenberg et al. (2018b, GEESD)

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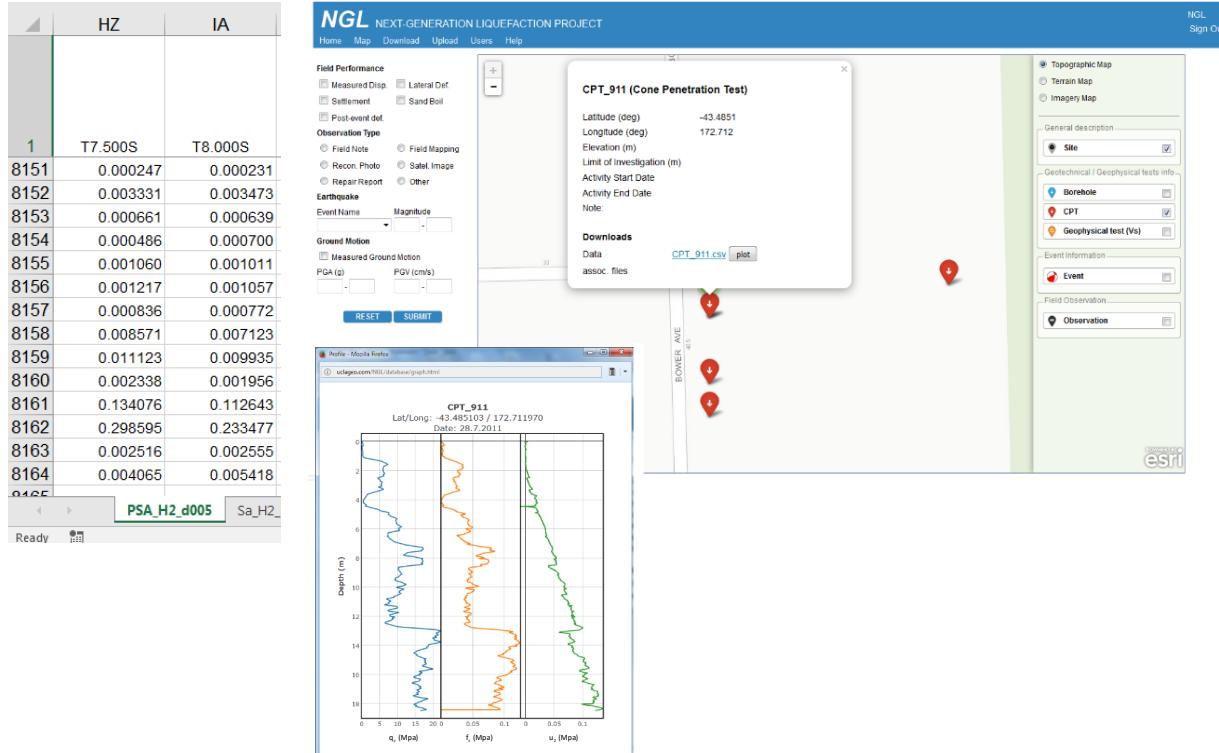
NGL case-history definition

NGL Database GUI development

Several beta-versions incorporating community inputs

**Ver. Beta_1
(csv + SQL)** → **Ver. Beta_2
(full SQL)** → **Official release (ver. 2.04)
(full SQL + Review)**

NGL Database GUI development

UCLA-SwRI Collaboration
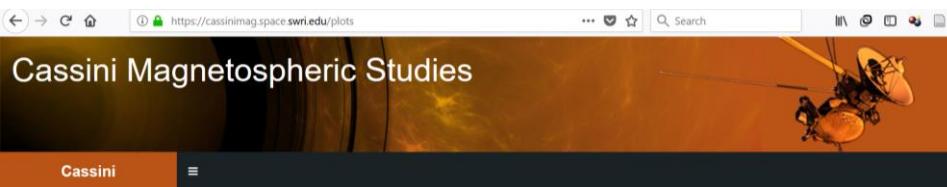
www.nextgenerationliquefaction.org
DOI: 10.21222/C2J040

NGL Database GUI Earthquake Events

NGA West 2 Database
NGA Subduction (soon...)

NGL Database GUI (Map view)

www.nextgenerationliquefaction.org

Site – Geotechnical characterization
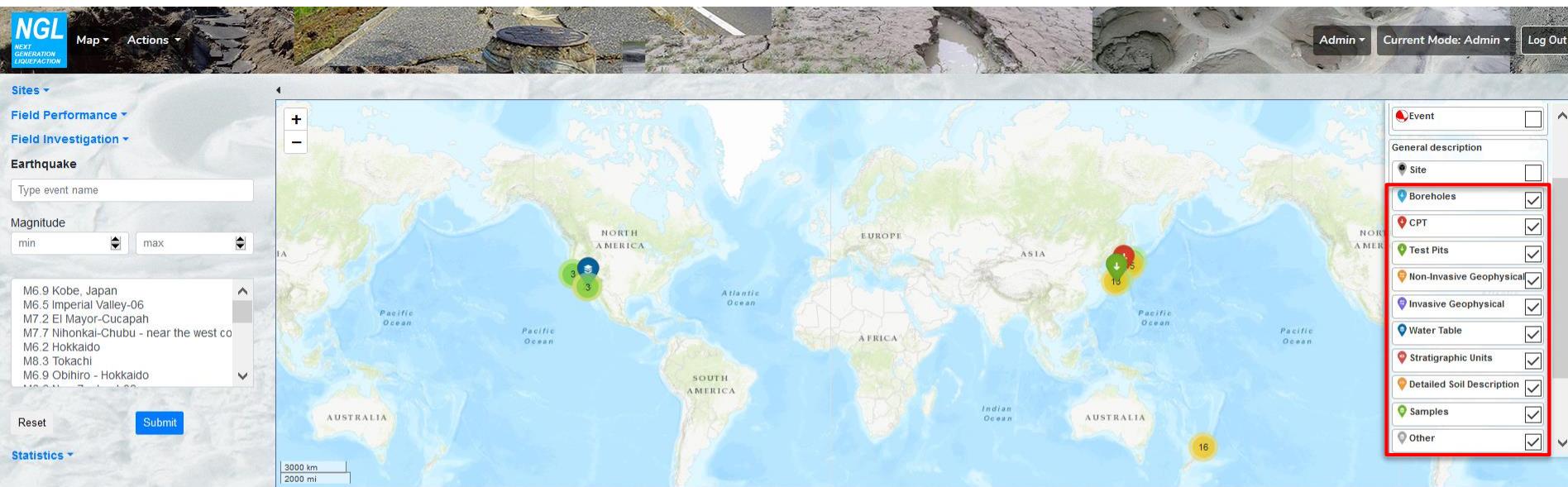
NGL Database GUI (Map view)

www.nextgenerationliquefaction.org

Earthquake events (that produced observations)

NGL Database GUI (Map view)

www.nextgenerationliquefaction.org

Post-earthquake observations

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NGL Database GUI (Map view)

www.nextgenerationliquefaction.org
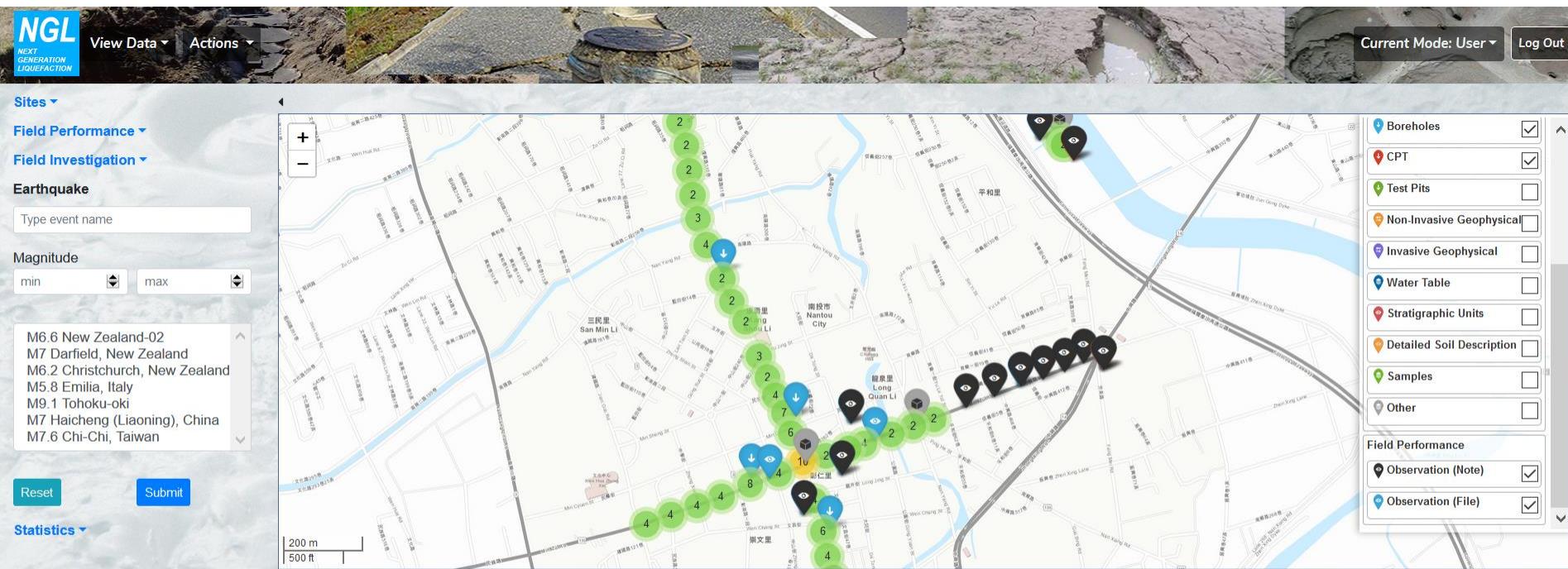
NGL Database GUI (Map view)

www.nextgenerationliquefaction.org
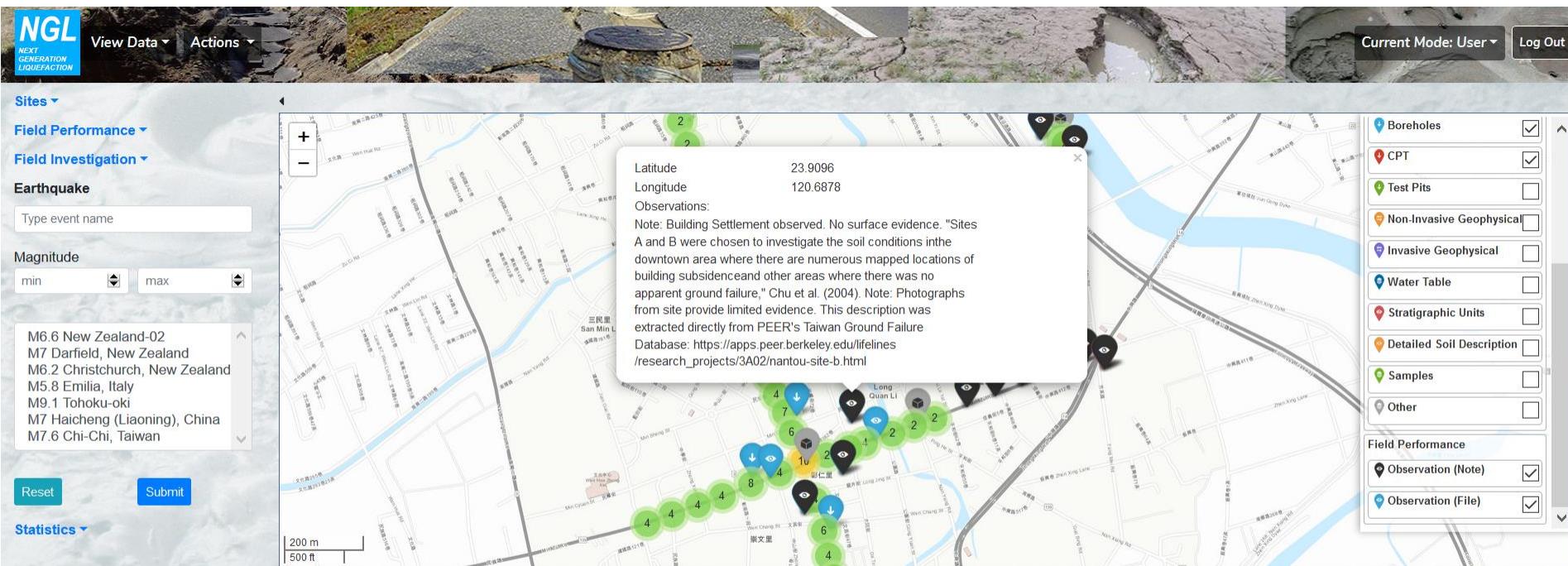
NGL Database GUI
(List view and functionalities)

www.nextgenerationliquefaction.org

NGL Database GUI
(How to upload a case history?)

www.nextgenerationliquefaction.org

1. Using the online guided step-by-step procedure

2. Using a pre-populated csv template (empty template + metadictionary provided)

NGL Database GUI
(How to upload a case history?) metadictionary

http://nextgenerationliquefaction.org/schema/index.html

NGL Database Home   Schema index   Tables   Columns   Constraints   Relationships   Orphan Tables   Anomalies   Routines

Tables

SchemaSpy Analysis of NGL_11_19_2018

Generated on Tue Nov 27 12:08 PST 2018

XML Representation
Insertion Order Deletion Order

TABLES 55	**VIEWS** 0	**COLUMNS** 475	**CONSTRAINTS** 63	**ANOMALIES** 0	**ROUTINES** 0

Database Properties ⚙

Database Type: MySQL - 5.6.34-log

Tables

All   Tables   Views   Comments

Search:

Table / View	Children	Parents	Columns	Rows	Type	Comments
BORH	0	1	11	0	Table	General information for boreholes

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Database Current Status

- Legacy case-histories (used in the past for model development) are in the process of being added (~300 case histories)

- Case histories with co-located recording stations

- Recent case histories
  - Christchurch 2010-2011 sequence (New Zealand)
  - Tohoku 2011 **M**9.1 earthquake (Japan)
  - Emilia 2012 **M**5.9 (Italy)

- Stable database GUI officially released on 09/24/2018

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Database Current Status

- Christchurch (New Zealand) 2010-2011 sequence:

Green et al. (2014) case histories (VTech Green and Ulmer)
25 sites, 50 case histories (Complete - under review)

Tonkin + Taylor case histories (Van Ballegooy and Liu)
37 sites, 135 case histories (Complete – will be under review soon)

UC Berkeley sites (Bray and Beyzaei)
10 sites, 20 case histories (Complete - under review)

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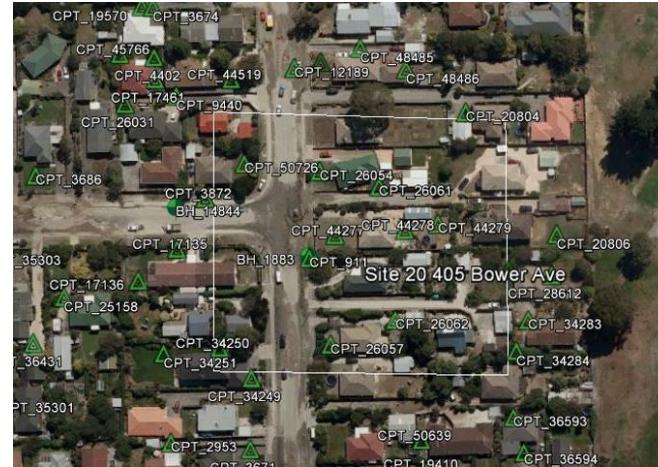
Database Current Status

- Tohoku (Japan) 2011 **M**9.1 event – Unpublished

Urayasu + Mihama - UCLA
2 sites/case histories (Complete – under review)

Instrumented levee arrays - UCLA
3 sites/case histories (Complete –under review)

Additional lateral spread sites – UCLA-BYU
3 sites/case histories (work in progress)

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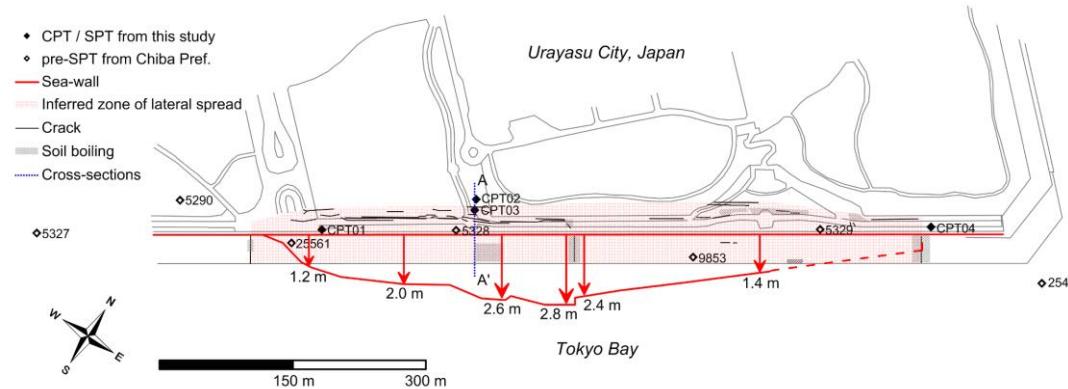
Database Current Status

- Case histories with co-located recording stations
 (Kramer and Greenfield (U. Washington)
  16 sites, 22 case histories (Complete - under review)

Ibaraki, Japan (2011 – Tohoku):
from Kramer et al. (2016) and
M. Greenfield pers. comm.
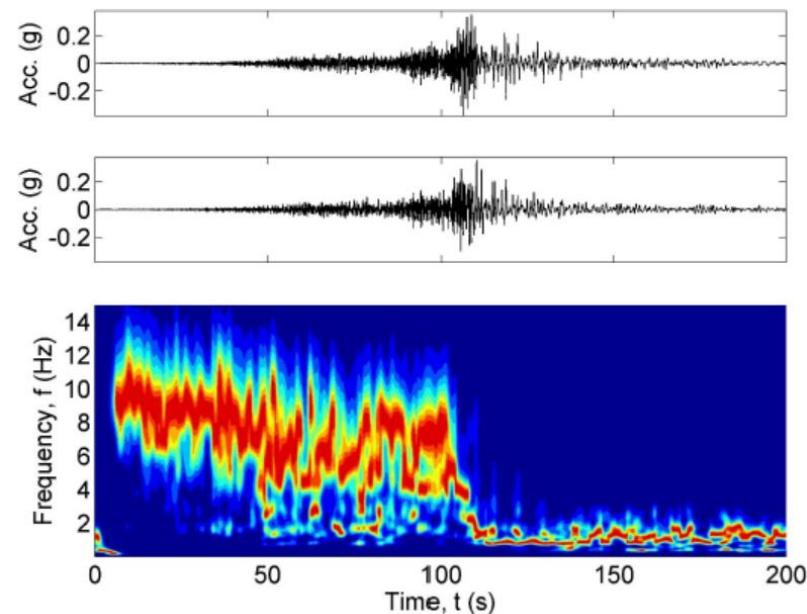
- Emilia (Italy) 2012 **M**5.8 earthquake – UCLA
  4 sites/4 case histories (Complete - will be under review soon)

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Review/Vetting Process

NGL Database working group

Purpose: to verify that required fields are present and the inputs match source materials.

Bi-weekly **meetings.**

Standardized procedure to look at data.

Review performed via **NGL graphical interface** – easy process!

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Vision for Community Access
## (*to cloud or not to cloud?*)

- **Large amount of data**, processing them on a laptop is inefficient (but still possible).
- The database is mirrored onto **DesignSafe** (www.designsafe-ci.org). Cloud-based tools (i.e. Jupyter notebooks)

This post-processing tool generates CPT/SPT/VS profile for each case history in the NGL database. Queries are produced for earthquake events that produced observations and sites for which geotechnical data are available.

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Vision for Community Access (*to cloud or not to cloud?*)

- **Large amount of data**, processing them on a laptop is inefficient (but still possible).
- The database is mirrored onto **DesignSafe** (www.designsafe-ci.org). Cloud-based tools (i.e. Jupyter notebooks)

Final Remarks

- Release of stable database GUI: ***nextgenerationliquefaction.org***

- The NGL relational database (being populated): capabilities for big data analytics

- Vetted database (NGL working group)

- NGL-NGA interaction – earthquake events

- The NGL database is mirrored onto DesignSafe – Cloud-based analytics

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Thank you!

Questions?

Relevant References

Brandenberg S.J., Kwak D.Y., Zimmaro P., Bozorgnia Y., Kramer S.L., Stewart J.P. (2018). Next-Generation Liquefaction (NGL) Case History Database Structure. Fifth decennial Geotechnical Earthquake Engineering and Soil Dynamics Conference, Earthquake Engineering and Soil Dynamics Committee of the Geo-Institute. Austin, TX (USA), June 10-13.

Zimmaro P., Kwak D.Y., Brandenberg S.J., Stewart J.P. (2018). NGL: An Open Source Global Database for Next-Generation of Liquefaction Assessment. SSA-LACSC scientific conference - Seismology of the Americas. Miami, FL (USA), May 14-17.

Stewart J.P., Kramer S.L., Kwak D.Y., Greenfield M.W., Kayen R.E., Tokimatsu K., Bray J.D., Beyzaei C.Z., Cubrinovski M., Sekiguchi T., Nakai S., Bozorgnia Y. (2016). PEER-NGL project: Open source global database and model development for the next-generation of liquefaction assessment procedures. Soil Dyn. Earthquake Eng., 91, 317–328.

Project homepage:
https://uclageo.com/NGL/

Database:
DOI: 10.21222/C2J040
http://nextgenerationliquefaction.org

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