International Workshop on Source Term Estimation Methods

Damon Room

National Center for Atmospheric Research

Boulder, CO

22-23 February, 2012

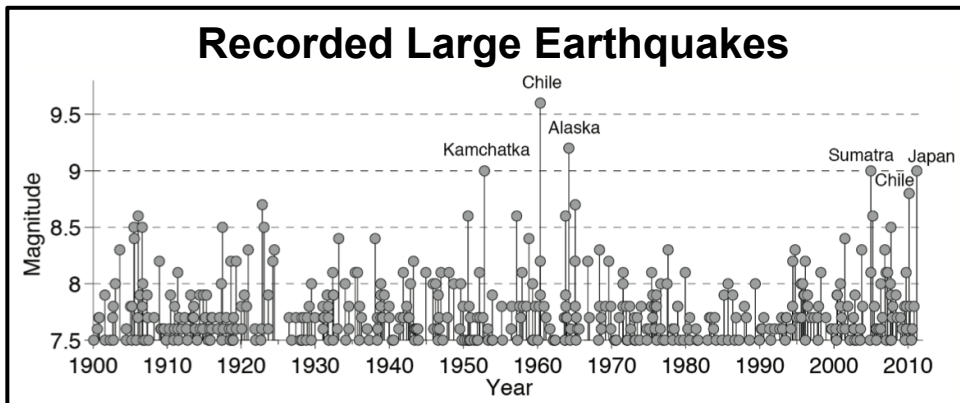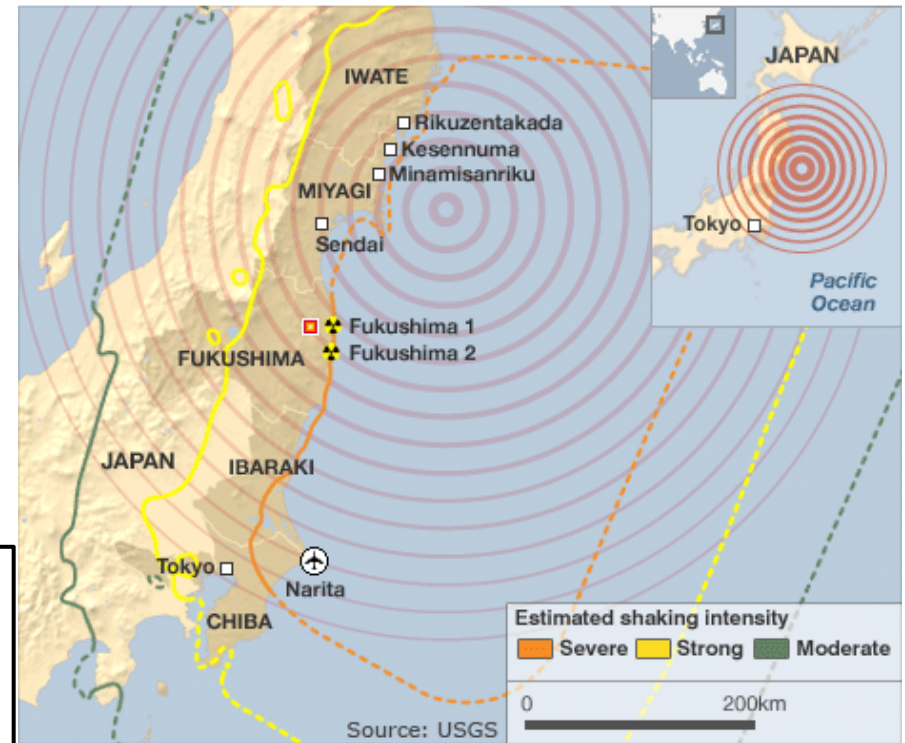NCAR/RAL - National Security Applications Program

Fukushima Dai-ichi Power Plant Accident
(Tohoku, Japan Earthquake)

- **Fifth largest earthquake on record**
  - **9.0 on the Richter scale**
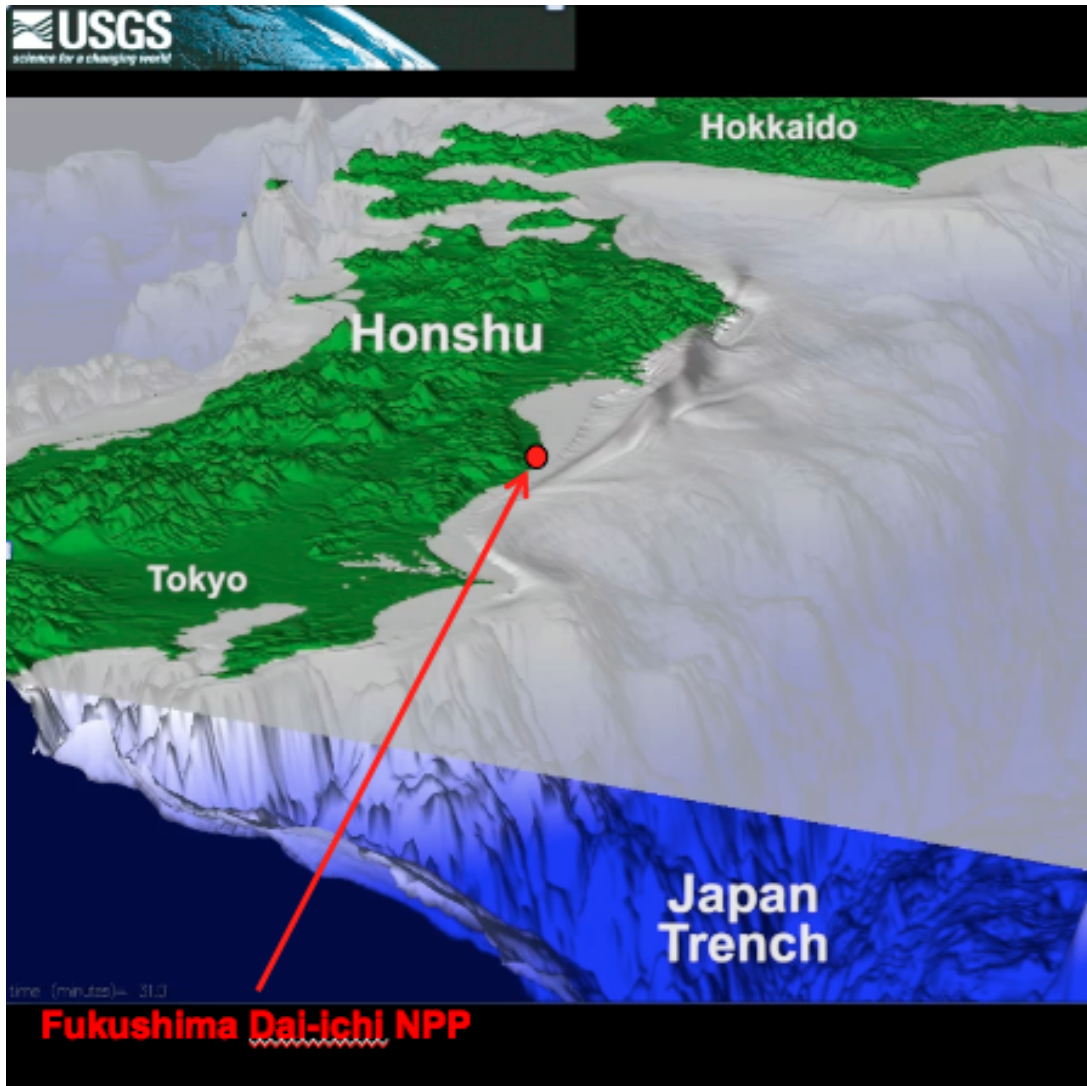 - **Models suggest plate shifts in excess of 30 meters**

Recorded Large Earthquakes

Source: The 03/11/2011 Mw9.0 Tohoku, Japan Earthquake – USGS NEIC (USGS-2011)
http://earthquake.usgs.gov/learn/topics/Tohoku2011.pdf

Fukushima Dai-ichi Power Plant Accident
(Subsequent Tsunami Following the Earthquake)

- **A massive tsunami followed**
  - **38.9 m wave recorded at Aneyoshi, Miyako**

- **Wave height at Fukshima Dai-ichi NPP**
  - **Estimated at 14-15 m**
  - **Design basis: 5.7 m**

Fukushima Dai-ichi Power Plant Accident
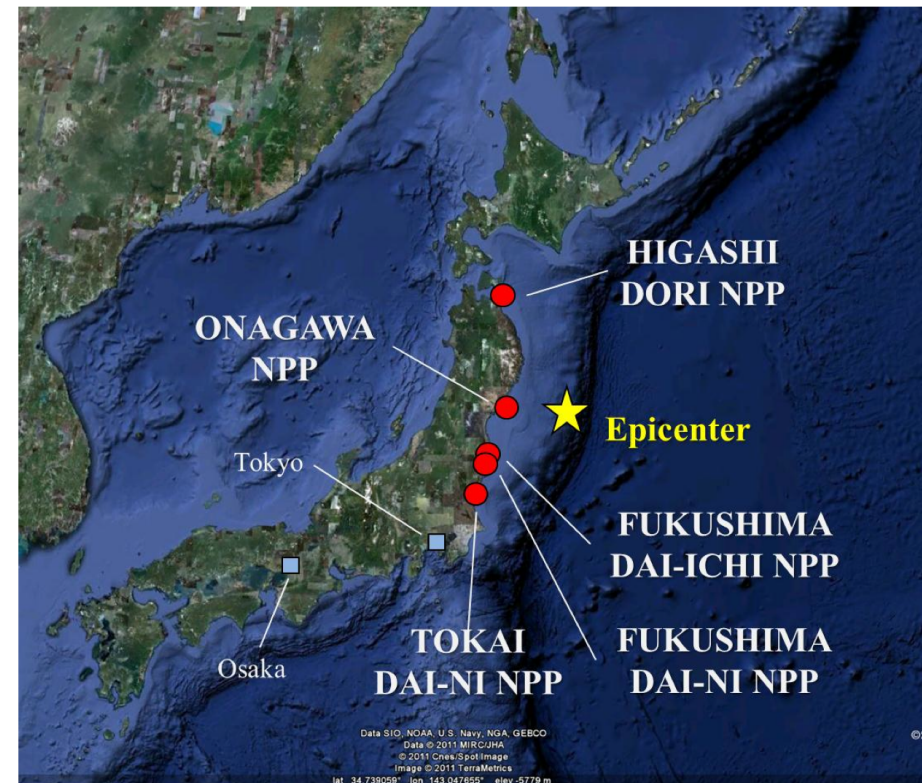## (Nuclear Power Plants (NPP) Affected by 2011 Earthquake)

Operational Status of NPPs Affected by Earthquake

NPP	Unit	Type		Capacity (MW(e))	Status		
		CV** type	Safety system		Before earthquake	After earthquake	After tsunami
Higashi Dori	1	Mark I R	BWR-5	1,100	Outage	Cold Shutdown	Cold Shutdown
Onagawa	1	Mark I	BWR-4	524	Operating	Automatic Scram	Cold Shutdown
	2	Mark I	BWR-5	825	Reactor Start	Automatic Scram	Cold Shutdown
	3	Mark I	BWR-5	825	Operating	Automatic Scram	Cold Shutdown
Fukushima Dai-ichi	1	Mark I	BWR-3	460	Operating	Automatic Scram	Loss of Cooling
	2	Mark I	BWR-4	784	Operating	Automatic Scram	Loss of Cooling
	3	Mark I	BWR-4	784	Operating	Automatic Scram	Loss of Cooling
	4	Mark I	BWR-4	784	Outage	Cold Shutdown	Loss of SFP* cooling
	5	Mark I	BWR-4	784	Outage	Cold Shutdown	Cold Shutdown
	6	Mark II	BWR-5	1,100	Outage	Cold Shutdown	Cold Shutdown
Fukushima Dai-ni	1	Mark II	BWR-5	1,100	Operating	Automatic Scram	Cold Shutdown
	2	Mark II R	BWR-5	1,100	Operating	Automatic Scram	Cold Shutdown
	3	Mark II R	BWR-5	1,100	Operating	Automatic Scram	Cold Shutdown
	4	Mark II R	BWR-5	1,100	Operating	Automatic Scram	Cold Shutdown
Tokai Dai-ni	-	Mark II	BWR-5	1,100	Operating	Automatic Scram	Cold Shutdown

*: Spent Fuel Pool
**: Containment Vessel

NPP Locations

Source: IAEA International Fact Finding Exert Mission, 05.24.2011 – 06.02.2011 (IAEA-2011)

Fukushima Dai-ichi Power Plant Accident
(Pictures of the Fukushima Dai-ichi NPP)

Fukushima Dai-ichi Before

Airborne Releases of Radiation

NEW EXPLOSION AT FUKUSHIMA DAIICHI NUCLEAR REACTOR
March 13, 2011. Hydrogen explosion at Unit No. 3. (*Nippon News Network*)

Fukushima Dai-ichi After

Source: IAEA International Fact FindingExert Mission, 05.24.2011 – 06.02.2011(IAEA-2011)

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NEW EXPLOSION AT FUKUSHIMA DAIICHI NUCLEAR REACTOR
March 13, 2011. Hydrogen explosion at Unit No. 3. *(Nippon News Network)*

Workshop Purpose and Goals
(Charter for Workshop Attendees)

- **Survey of relevant information**
  - **The event**
  - **Available observational data**
  - **Source term estimation (STE) methods**
  - **Analysis/modeling of relevant physical processes**

- **Define the current state-of-the-science for topics above**

- **Identify relationships between the various topics**

- **Identify and prioritize gaps**
  - **Knowledge**
  - **Capabilities**
  - **Data**

- **Provide recommendations for a path forward**

Things to Keep In Mind

- **Keep your descriptions/presentations at a high level**
  - **Want to facilitate discussions between technical disciplines**

- **Try to relate your briefing in the context of the overall problem**

- **Take advantage of the broad spectrum of expertise**
  - **Radiation observation collection/analysis expertise**
  - **NPP and radiation modeling expertise**
  - **STE modeling expertise**
  - **Meteorological expertise**

- **Look for innovative new solutions that take advantage of the things you hear from colleagues here at the workshop**

Workshop Agenda
(Technical Presentation Portion of the Meeting)

- **Session I: Review of Fukushima Dai-ichi NPP radiation release and response**

- **Session II: Observations from the accident**

- **Session III: Methods for STE for atmospheric releases**

- **Session IV: Methods for STE for atmospheric releases (cont.)**

- **Session V: Atmospheric data assimilation and modeling of relevant physical processes**

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Workshop Agenda
(Break-out Session Portion of the Meeting)

- **Break-out group I: Observations**

- **Break-out group II: Uncertainty and physical process modeling**

- **Break-out group III: Back-trajectory category STE methods**

- **Break-out group IV: Non-gradient descent forward model descent STE methods**

- **Break-out group V: Gradient descent and other STE methods**

Suggested Break-out Group Procedure

- **We will break out into separate smaller sub-groups based on expertise**
- **Consolidate and summarize the findings on the sub-group topic**
- **Document findings in a presentation and sub-group notes**
- **Present sub-group findings to the whole workshop in plenary session**

Workshop Logistics

- **Restrooms**
  - **Across the atrium past science exhibits**

- **Coffee breaks**
  - **Coffee, tea, soft drinks, water and snacks provided**

- **Lunches**
  - **No-host lunch available in the NCAR Mesa Lab cafeteria**
  - **Down the hill in Boulder**
    - **May be difficult to get there and back in the time available**

- **NCAR tour on Wednesday afternoon at 16:00**

- **Workshop group dinners**
  - **No-host dinners in Boulder on Wednesday and Thursday evening at 19:00**
  - **Printed directions will be provided**

- **If there is anything you need please ask!**

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Session VIII –   Poster Sessions

Posters will be available for viewing and discussion during all of the session coffee and lunch breaks. The posters will also be included in the break-out session discussions.

P1.	*Radiological Source Characterization Using L1 norm Minimization,* **Dr. Tarun Singh,** (State University of New York at Buffalo)

P2.	*Application of the HYSPLIT Model for Source Term Estimation,* **Lori Mandable,** (George Mason University)

Wednesday, February 22, 2012

08:00   *Continental breakfast*

08:30   *Welcome and Introduction,* **Dr. Brant Foote, Scott Swerdlin, and Dr. Paul E. Bieringer**

Session I –	**Review of Fukushima Daiichi Nuclear Power Plant Atmospheric Radiation Release and Response**

09:00   *Introduction of Fukushima Event and Response Session,* **Dr. Paul E. Bieringer**, *(National Center for Atmospheric Research)*

09:05   *Introduction of Fukushima Daiichi Nuclear Power Station Accident,* **Ms. Tomomi Matsunaga,** *(Kansai Electric Power Company)*

09:20   *The Defense Threat Reduction Agency (DTRA) Operational Response for The Fukushima Daiichi Nuclear Power Plant Accident,* **Dr. John Hannan,** *(Defense Threat Reduction Agency)*

09:40   *NARAC Source Reconstruction During the Response to the Fukushima Dai-ichi Nuclear Power Plant Emergency,* **Gayle Sugiyama and John Nasstrom,** *(Lawrence Livermore National Laboratory)*

10:00   *Session I – Q&A and discussion*

10:20   *Coffee break*

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Workshop Agenda
(Session II – Wed, February 22)

Session II –   Observations from the Fukushima Accident

10:40   *Introduction of Fukushima Observations Session,* **Dr. Paul E. Bieringer**,
(National Center for Atmospheric Research)

10:45   *Report on a Recent Field Program to Collect Radiation Measurements
Surrounding the Fukushima Nuclear Power Station,* **Dr. Ryohji Ohba,**
(Japan Nuclear Safety Research Association)

10:55   *Description of Observations Collected Around the Fukushima Site by the
US DOE Teams*, **Dr. Steve Kreek,** (Lawrence Livermore National
Laboratory)

11:15   *CTBTO Radionuclide Detections in the Aftermath of the Fukushima
Release and a Necessity for Improved Source Inversion Algorithms,* **Dr.
Monika Krysta,** *(Comprehensive Nuclear-Test-Ban Treaty Organization –
(CTBTO))*

11:35   *Session II – Q&A and discussion*

12:00   *Lunch (NCAR Mesa Laboratory Cafeteria)*

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Workshop Agenda
(Session III – Wed, February 22)

Session III –	Methods for Source Term Estimation of Atmospheric Radiation Release

13:00   *Introduction of Wednesday STE Methods Session, **Dr. Paul E. Bieringer**,* (National Center for Atmospheric Research)

13:05   *Survey of Estimation Methods for Amount of Radioactive Materials Emitted from the Nuclear Power Station During Severe Accident, **Dr. Ryohji Ohba,*** (Japan Nuclear Safety Research Association)

13:15   *Source Term Estimation and Atmospheric Dispersion Simulations of Radioactive Materials Discharged from the Fukushima Daiichi Nuclear Power Plant due to Accident, **Dr. Haruyasu Nagai,*** (Japan Atomic Energy Agency)

13:45   *Development of an Estimation Method for the Amount of Radioactive Materials Emitted from the Nuclear Power Station During the Severe Accident, **Dr. Ryohji Ohba,*** (Japan Nuclear Safety Research Association)

14:15   Back-trajectory Based Methods for Source Parameter Estimation, **Dr. Andrew Annunzio,** (National Center for Atmospheric Research)

14:30   *Coffee break*

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Session III –	Methods for Source Term Estimation of Atmospheric Radiation Release

14:45   *Source Term Estimation for the 2011 Fukushima Nuclear Accident,* **Dr. Guido Cervone,** (George Mason University)

15:05   *Polynomial Chaos Based Minimum Variance Approach for Characterization of Source Parameters,* **Dr. Tarun Singh,** (State University of New York at Buffalo)

15:25   *Estimation of Errors in Inverse Modeling of Accidental Release of Atmospheric Pollutant: Application to the Reconstruction of the Cesium-137 and Iodine-131 Source Terms from the Fukushima Daiichi Power Plant,* **Dr. Marc Bocquet,** (University of Paris)

15:45   *Session III – Q&A and discussion*

16:00   *NCAR Tour*

17:00   *Adjourn*

19:00   *No host dinner*

Workshop Agenda
(Session IV – Thurs, February 23)

Session IV –	Methods for Source Term Estimation of Atmospheric Radiation Release (Continued)

08:00   *Continental breakfast*

08:30   *Introduction of Thursday STE Methods Session,* **Dr. Paul E. Bieringer**, (National Center for Atmospheric Research)

08:35   *A Survey of Evolutionary and Probabilistic* Approaches to the *Estimation of Sources for Atmospheric Releases of Contaminants*, **Dr. Branko Kosovic,** (National Center for Atmospheric Research)

08:55   *Estimation of Source Parameters for Hazard Releases*, **Dr. Gareth Brown,** (UK Defense Science and Technology Laboratory (Dstl))

09:15   *An Adjoint Approach for the Estimation of Source Terms for Atmospheric Releases,* **Luna Rodriguez** (National Center for Atmospheric Research)

09:35   *Session IV – Q&A and discussion*

10:00   *Coffee break*

Workshop Agenda
(Session V – Thurs, February 23)

Session V –	Atmospheric Data Assimilation, Modeling, and Relevant Physical Processes

10:15   *Introduction to Atmospheric Modeling and Physical Processes Session,* **Dr. Paul E. Bieringer**, (National Center for Atmospheric Research)

10:20   *Mesoscale Modeling and Data assimilation for Atmospheric Transport and Fate of Radioactive Materials,* **Dr. Yubao Liu,** (National Center for Atmospheric Research)

10:40   *Modeling the Physical Processes that Impact the Fate and Fall-out of Radioactive Materials,* **Van Ramsdell,** (Pacific Northwest National Laboratory)

11:00   *Session V – Q&A and discussion*

11:30   *Lunch (NCAR Mesa Laboratory Cafeteria)*

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Session VI –   Session Break-out Groups

13:00   *Introduction to Break-out Group Session,* **Dr. Paul E. Bieringer**, (National Center for Atmospheric Research)

13:05   Discussions on topics presented in previous sessions (designated facilitators will facilitate discussion, prepare, and present reports)

Break-out group discussion (each group will consist of about 4-8 members)

- Define current state of the topic
- How does it relate to other STE methods of breakout topics
- Identify and prioritize gaps
- Suggest path forward

Break-out group report preparation (group discussion facilitators prepare reports with help from group members)

14:45   *Coffee break*

Suggested Breakout Session Groups

Session 1: Back-trajectory Methods for Source Term Estimation	Session 2: Observations
Annunzio (chair) Della Monache Krysta Mandable Madankan Hurst	Bieberbach (chair) Kreek Hanna Swanson Van Ramsdell

Session 3: Uncertainty and Physics	Session 4: STE Using Optimization With Forward Models (Non-Derivative Methods)
Rodriguez (chair) Weil Matsunaga Sugiyama Meroney Peterson Liu Cabell	Kosovic (chair) Haupt Nasstrom Nagai Brown Redwood

Session 5: STE Using Optimization (Derivative Methods and Other Methods)	
Vandenberghe (chair) Young Singhe Cerone Aidondis Bocquet	

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Workshop Agenda
(Session VII – Thurs, February 23)

Session VII –	Plenary Session with Reports from Break-out Sessions

15:00	*Session I Break-out Session Report/Presentation*
15:15	*Session II Break-out Session Report/Presentation*
15:30	*Session III Break-out Session Report/Presentation*
15:45	*Session IV Break-out Session Report/Presentation*
16:00	*Session V Break-out Session Report/Presentation*
16:15	*Plenary session Q&A and discussion*
17:00	*Adjourn*
19:00	*No host dinner*