6. SESSION ON THE 11 MARCH 2011 JAPANESE EVENT AND ITS AFTERMATH

Conveners:

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ORAL PRESENTATIONS:

JS-O1. Source process and broadband waveform modeling of 2011 Tohoku earthquake using Spectral-Element Method

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We have calculated broadband synthetic seismograms for Mar. 11, 2011 Tohoku earthquakes using the Spectral-Element Method. We use finite source models by using a set of sub-events distributed along the fault surface, retrieved by inversion of body waves (Nakamura et al, 2010). The finite source model used in this simulation estimates Mw to be 9.1. The fault dimension is 460 km times 240 km with the source duration time of 150 sec. We use the Earth Simulator2 of JAMSTEC to calculate preliminary synthetic seismograms for this finite source model. We used 726 processors of the Earth Simulator 2, which should provide synthetic seismograms that are accurate up to about 5 second and longer. The comparison of the synthetic seismograms with the observation for this event shows that synthetic P-waveforms model the observed seismogram quite well, reflecting that the finite source model is quite precise. This source model shows that the maximum slip occurs at depth of 20 km and propagates to shallower region, which is consistent with the fact that the tsunami excitation was significant for this event. Azimuthal dependence of misfits of synthetic waveforms and observation, especially for surface waves, may reflect the discrepancies of three-dimensional mantle structure used in this simulation with the actual Earth. We also will discuss some of the phases recorded in association with these earthquake and tsunami on infrasound monitoring station at Isumi, Japan.

JS-O2. Magnitude determination using duration of high frequency energy radiation for the 2011 Off the Pacific Coast of Tohoku Earthquake

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We applied a technique to determine earthquake magnitudes using durations of high frequency energy radiation and the maximum displacement amplitudes to the 2011 Off the Pacific Coast of Tohoku Earthquake. The estimated duration of high frequency energy radiation is 170.5 s, which is consistent with the centroid time shift 69.8s from the Global CMT solution. The estimated magnitude is 8.96, which well agrees with preliminary analyses for this earthquake. Compared to the December 26, 2004 Sumatra earthquake (Mw 9.0), this event is characterized by shorter duration of high frequency energy radiation and larger displacement amplitude. We found azimuthal dependence of the measured durations of high frequency energy radiation, which suggests the rupture propagation in the southwest direction.

JS-O3. Analysis of the Fukushima accident by the French National Data Centre

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From 11th of March 2011 following the Earthquake/Tsunami leading to a severe accident at the Fukushima nuclear power plant, CEA-DAM through its National Data Centre has automatically and interactively processed and analysed the whole daily set of data provided by the Particulate and Noble gas Network radionuclide stations. In addition, the French laboratory, as support of the network of the International Monitoring System (IMS) in the frame of CTBT, has performed expert assessment of some IMS particulate samples, notably regarding specific fission products likely to help the understanding of the Fukushima accident scenario. More generally very useful feedback was achieved from these analyses dealing with the chronology of detections, amount of nuclear material released in the atmosphere, isotopic and chemical signatures. It was found that the high activity concentrations observed at the Takasaki, Japan stations, led to dead time and memory effect on the radionuclide detection systems, especially those related to the beta-gamma detection module for analysing xenon isotopes. As a consequence, the French NDC had to applied special procedures to be able to analyse the sample.

In parallel, atmospheric transport modelling at mesoscale and global scale was performed in order to predict the evolution of the plume on Japan area and on a worldwide scale. Atmospheric transport simulations exhibit good spatial and time agreement with detections from the radionuclide Network stations.

JS-O4. Tsunami infrasound: 2004 Sumatra and 2011 Tohoku case studies

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Infrasonic signal associated with tsunamigenesis appear to possess recurrent signal features which could be used for early event identification. From the 2004 Sumatra earthquake and tsunami we learned that infrasonic signals associated with the coseismic ground displacement near the epicenter appear to radiate primarily above 0.2 Hz. Deep infrasound in the 0.02-0.2 Hz range may be radiated by the vibration of distant mountain as well as be indicative of the interaction of a tsunami with coastline features and bathymetry. Below 20 mHz, acoustic-gravity waves can provide information on the very large scale (~1000 km) coseismic uplift and subsidence of the sea bottom and associated swelling and depression of the sea surface over the source region. We present observations of the 11 March 2011 Tohoku earthquake and tsunami by the IMS infrasound network and compare these observations with seismic and tsunami models, as well as with other geophysical characterizations of this event.

JS-O5. Canadian monitoring of Fukushima incident

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The March 11 seismic event near Japan and subsequent radionuclide observations caused by damage to the Fukushima Nuclear facility resulted in a verification scenario similar to the one that would arise after an atmospheric nuclear test. Large data sets generated from the International Monitoring System of the Comprehensive Nuclear Test Ban Treaty Organization and Canadian national equipment were analyzed to determine the nature and magnitude of the event. Various Canadian assets were used including: a network of NaI detectors, aircraft surveillance, high volume aerosol samplers, and soil samples to provide guidance to decision makers on the nature and impact of the event. A discussion of the tools used, their capabilities, and results will demonstrate how national technical means can complement the information received from the IMS and IDC.

JS-O6. A window into the complexity of the dynamic rupture of the 2011 Mw 9 Tohoku-Oki earthquake

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The Mw 9 earthquake that occurred off-shore Tohoku, Japan, on March 11 2011 is by far the best recorded earthquake in the history of seismology and will undoubtedly spawn a broad range of studies that will deeply transform earthquake science. In particular, this event provides a unique opportunity to address, through high resolution observations, fundamental questions about the physics of dynamic earthquake rupture, including the initiation of rupture, the complexity of its propagation and its arrest. Here we focus on key direct observations of the spatio-temporal evolution of the rupture process of the Tohoku earthquake. We analyze seismic data available soon after the event using source imaging methods that are weakly dependent on model assumptions. We backprojected teleseismic waveforms applying high-resolution array processing techniques to obtain a high-frequency (HF) image of the rupture process of this mega-earthquake. We then identified prominent features of the local strong-motion recordings that we associate to the main phases of the rupture process. Our results reveal, with unprecedented detail, rich patterns of high frequency radiation from the deep portions of the seismogenic

zone. Our observations open a direct window into the complexity of dynamic rupture, including phases of slow and extremely fast rupture, and its relation to the heterogeneous nature of the subduction interface.

JS-O7. Detection of elevated Xe-133 following the Fukushima nuclear accident

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We report on the first measurements of short-lived gaseous fission products detected outside of Japan following the Fukushima nuclear releases, which occurred after a 9.0 magnitude earthquake and tsunami on March 11, 2011. The measurements were conducted at the Pacific Northwest National Laboratory (PNNL), located more than 7000 km from the emission point. First detections of 133Xe were made starting early March 16, only days after the earthquake. Maximum concentrations of 133Xe were in excess of 40 Bq/m3, which is more than ×40,000 the average concentration of this isotope in this part of the United States.

JS-O8. Response of the Austrian Meteorological and Geophysical Service and the National Data Centre Austria to the nuclear accident in Fukushima: Atmospheric transport modelling and situation assessment based on CTBTO radionuclide data

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On 12 March 2011 at about 6:30 UTC (7:30 CET), the first explosion was reported from block 1 of the nuclear power plant in Fukushima Daiichi. Only minutes afterwards, the Meteorological and Geophysical Service of Austria (ZAMG) started its model simulation of the event. As transport model the Lagrangian Particle Diffusion model FLEXPART Version 8 based on input data from the European Centre for Medium-Range Weather Forecasts (ECMWF) was used. In its assignment as National Data Centre of Austria, ZAMG has real-time access to the global radioactivity data of CTBTO. These data were used to validate the model simulation, and to estimate the emission sequence of key radionuclides. Data and modeling results related to the accident were made available to the public. Results show that the ZAMG model worked well in describing the hemispheric-scale transport. CTBTO data and information disseminated to the member states through the secure web page and briefings proved to be extremely valuable for the assessment of the situation.

JS-O9. Operational experience of CTBTO related to the Fukushima nuclear accident and long term perspectives

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The release of fission and activation products from the Fukushima nuclear power plant on the aftermath of the 11 March 2011 Tsunami posed a number of challenging questions for the CTBTO radionuclide network. The challenges applied to the sample analysis, sample handling, sample dispatch, laboratory analysis, data analysis and atmospheric transport modeling. All the operational radionuclide stations in the northern hemisphere detected the release; most of the detections were initially level 5 samples (multiple fission products detected). The CTBT radionuclide system performed well during this event. Some lessons were learned about procedures needed for this kind of situation handling in the future and also on possible dynamic range of the future measurement equipment.
The CTBTO is involved in the worldwide response to the Fukushima events. Although this response was not based on any preparedness plan and procedures, it appears to fit well the purpose because of the performances of the network and the usefulness of the measurements that are made available to the Member States and the international community. The results provided by the network will continue to have a key role to facilitate the various decision-making processes also during post event phase. In that perspective, the relationships need to be considered between CTBTO and the other international organizations involved in the response to nuclear emergencies, including Fukushima. The presentation identifies some subjects that need to be considered in this kind of co-operation.

POSTER PRESENTATIONS:

JS-P1. Pressure signals on IMS hydrophones at Wake Island due to the M9.0 event on March 11th 2011 off the coast of Japan

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International Monitoring System Hydrophone sensors at Wake Island measured three different types of pressure signal as a result of the magnitude 9.0 event that occurred off the coast of Japan on the 11th of March 2011. Acoustic pressure signals were first recorded as the seismic phases from the event propagated past hydrophone locations, causing radiation of acoustic signals into the water. Next, the acoustic T-phase was detected as sound that coupled into the ocean near the event epicenter reached Wake Island. Finally the tsunami generated by the event was observed as it passed over the hydrophones, changing local sea level and consequently generating a low-frequency pressure signal. These data are displayed and the features of each signal discussed.

JS-P2. Assessment of release scenarios for the Fukushima Dai-ichi Nuclear Power Plant accident

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Dispersion of radioactive material released to the atmosphere from the Fukushima Dai-ichi Nuclear Power Plant Accident in Japan was modelled to assist the Australian Government in effectively providing public health advice to its citizens. This advice on protective measures required estimation of radiation doses for locations in Japan based on credible scenarios and atmospheric dispersion modelling. To undertake the assessment relied on deriving an appropriate nuclear reactor source term and accident release scenario that could be matched against the limited observational data. Evaluation of the atmospheric dispersion model and its input source term and release scenario was undertaken by comparison and refinement of predictions with concentration measurements taken downwind from the actual release. Short-range forward dispersion analyses were used to refine rel! ease magnitudes for different release times to deliver the activity concentrations measured at the Comprehensive Nuclear-Test-Ban Treaty radionuclide station at Takasaki, Gunma, Japan, using a 1% core release scenario with predictive weather conditions. Further comparisons were then made to ground based gamma dose measurements, estimated release rates and long range atmospheric dispersion modelling. This paper presents the approach taken to justify the release scenario by coupling monitoring data with atmospheric simulations.

JS-P3. Source modeling earthquake as tsunami generation in Japan (East of Pacific Plate)

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In most cases, an earthquake occurring next to a coastline segment generates a tsunami in a relatively short time. The West of Pacific area has experienced repeated large earthquakes, such as the Japan event on March 11, 2011. The time at which the tsunami disaster will occur, the arrival time, how high (run-up) the waves are, and the extent of the resulting immersion area (Inundation) and the simulation can be calculated by creating a tsunami modeling scenario. To create tsunami modeling parameters, millions of fault scenarios should be tested in anticipation of a possible tsunami on the plate boundary segments prone to tsunamis, for instance in the Western Pacific in the case study on plate boundary of pacific . The Scenarios were prepared based on the values of fault parameters and will bemodified in such a way as to produce the fault model which match the future expected fault conditions on this segment. Estimating the fault location on the segment can be done by observing crustal deformation or relative motion of the earth's crust, or in complex cases such as the movement of the double-couple in the crust, can be obtained by calculating and analyzing historical data and then validating the result by comparing to survey results. Also, another criterion for prediction of tsunami run-up and

tsunami inundation is to do it based on calculation of released energy of earthquake and the return period of earthquakes at this location.

JS-P4. Experimental check of work on an adaptive algorithm for detection of onset times of low amplitude seismic phases based on time series analysis with use of Japan earthquakes data records in March 2011

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The ultimate goal of processing is to measure the characteristics of a useful signal in a situation where the seismogram is a complicated superposition of very different types of wave motion. The very process of obtaining these characteristics can be viewed as a mathematical problem in its own right. The process is based on a search for patterns that connect the original signal to the physical parameters listed above, as well as formulating these patterns as efficient computational techniques. Unlike the Fourier transform, the wavelet transform provides a 2D representation of the signal under study, frequency and time being treated as independent variables. As a result, we are able to examine the properties of the signal in a physical space (the time) and a scale space (the frequency). The algorithm in question is designed for the fastest real time detection of a sudden change in the properties of a process as more information is becoming available. The problem is formulated so that the onset of low amplitude seismic phases is to be automatically identified during a time interval no longer than four seconds. The algorithm is based on the continuous wavelet transform. This is an adaptive algorithm, since it incorporates time-dependent individual characteristics of the time series of interest.

JS-P5. The International Data Centre analysis of the aftershock sequence following the March 11, 2011 earthquake off the coast of Japan

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The M9.0 megathrust earthquake off the coast of Japan on 11 March 2011 resulted in an unprecedented number of aftershocks being built by the automatic processing system of the CTBTO. These aftershocks imposed a workload on the waveform analysts of its International Data Centre (IDC) which was many times the average, falling back close to the average only after some months; the ensuing analysis of the sequence therefore took some months to complete. The IDC draft operational manual prescribes that the daily reviewed bulletin must be completed within 48 hours of the end of the recording day 98% of the time after Entry into Force (EIF) of the Treaty. Events such as this Japanese earthquake sequence will impose an even greater challenge to this schedule than it does upon the current pre-EIF target of issuing the reviewed bulletin within ten days. The results of the analysis of the aftershock sequence are presented and examined in terms of the scientific outputs, the impact on analysis, and lessons learned for the IDC. In view of the cumulative delay in analysis created by a prolonged aftershock sequence, meeting of the post-EIF requirement is favoured by skipping days entirely early in the sequence, to avoid a prolonged failure to meet the imposed target. The formulation of this requirement may therefore need review.

JS-P6. Bulgarian experience with Fukushima event in March 2011

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After the Chernobyl accident the Bulgarian population is extremely sensitive to radioactivity. Even follow the rumors of possible increasing of radioactivity in the environment a lot of people took some non-useful medicines "to protect" their health. Due to the possible impact of the accident at the Fukushima nuclear power plant we have to organize proper radiation protection for the population. It was of prime importance to know the level of radioactivity transferred in the air from Japan to Bulgaria.
As the NCRRP is a part of the Bulgarian NDC to the IDC of CTBTO, we use the data from the IDC. We follow the IDC ATM and make our model of the level of radioactivity and data of upcoming radioactive particles in Bulgaria. We found 25 March was the first day of the Fukushima impact. Every day we checked the data for North transfer from the SEP63 FOI, Stockholm Sweden, and the data for the West transfer from DEP33 Schauinsland/Freiburg, Germany. It was very important to know at least 2-3 days in advance the possible radionuclide content in the Bulgarian air.
In the paper are presented Bulgarian measurements of the radionuclides content in the air. We sampled at least 350 m3 of air every day and provide gamma spectrometry analyses of at least 0.017 mBq/m3 and±16 hours. The specific activity of I-131 varies between 0.052 0.026±0.018 mBq/m3. The activity of Cs-137 and Cs-134 varies from 0.054±1.92 0.07 mBq/m3 respectively. We±0.06 mBq/m3 and from MDA to 0.0477±mBq/m3 to 0.63 measured traces of Cs-136, Te-132 and I-132. The results are compared with IDC data for the DEP33, SEP63 and JPP38 station results.
The CTBTO data from the radionuclide monitoring system are very useful for the prediction and assessment of the public dose, taking decisions and informing the population.

JS-P7. Infrasound signals excited by upheaval and subsidence of ocean surface during the tsunami genesis related to 11 March event

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Observed infrasound records at IMS stations in East Asia relating to the disastrous tsunamigenic earthquake occurred at Mar. 11, 2011 in Japan had been analyzed. And long period acoustic signals which might be excited by uplifting and subsiding ocean surface during the tsunami genesis were detected in the records observed at I30JP, I34MN and I45RU. The on-set time of these signals coincided with the time predicted by the distance between the tsunami source region and each station, and the shape of these signals also coincided with the water level changes of the tsunami source estimated by the fault model of the event. I34MN and I45RU are located the direction along the fault width, and I30JP is located the direction along the fault length. Infrasound signals observed at both I34MN and I45RU had relatively shorter wave lengths than the signal of I30JP had. It also coincided with the geographical relation between the tsunami source and stations. When Tsunami early warning provides to the public, the possibility of the tsunami occurrence and its height are estimated by only using the hypocenter location and the magnitude and not using the information about the tsunami source area and actual initial height in the source region, therefore, Tsunami warning may not have enough accuracy now. According to the analysis results, if infrasound observation network would deploy along the coast line at the front of subduction zone, real-time data observed through the network would improve the tsunami warning information.

JS-P8. Detection of aerosol radionuclides in the United States following the Fukushima nuclear accident

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Several measurements of aerosol radionuclides emitted by Fukushima reactors were made in the United States. These included 131I, 137Ce, and others up to a few milliBq per cubic meter. Isotopic ratios clearly distinguish this event from other observations, such as Chernobyl and historic weapons tests, showing a strength of the International Monitoring System design.

JS-P9. Some measures to face potential impacts of Fukushima nuclear accident in Burkina Faso

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The probability for the Burkina Faso local population to develop deterministic effects after Fukushima nuclear accident is zero. However, stochastic effects remain possible as the two countries have concluded multilateral and bilateral agreements, particularly in the field of international trade in product for human or animal consumption and the possibility for their people to travel to/from Japan. Therefore, the Burkina Faso nuclear safety regulatory body has implemented a strong and sustainable strategy to avoid any negative impact both to the environment and the health of populations. Actions related to sensitization, communication and information with regard to the accident had been conducted in order to reduce the widespread fear of nuclear. For the time being, the national legislative framework has been improved, focusing on (i) authorization certificate b! efore food importation from Japan, (ii) in situ inspection in collaboration with customs and the National Public Health Laboratory prior to consumption or sale in local markets and (ii) compliance with the IAEA code of conduct related to radiological food analysis. The long term strategy aims to build a Radionuclide identification laboratory using gamma spectrometric methods. For this purpose to be achieved, staff capacity building is needed as technical assistance and expert advice have been obtained from the IAEA and the United States Department of Energy through the Global Threat Reduction Initiative already.