Outcomes of the International Volcanic Ash Task Force 2010 2012

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The International Volcanic Ash Task Force (IVATF) was established by the International Civil Aviation Organization (ICAO) in May 2010 in response to the significant disruptions of civil aviation that resulted from the eruption of Eyjafjallajokull. Working in a complementary capacity to the existing ICAO International Airways Volcano Watch (IAVW) Operations Group (IAVWOPSG), the task force was principally tasked to assist in the urgent development of a global safety risk management framework that would make it possible to determine the safe levels of operation in airspace contaminated by volcanic ash. Recognizing the multi-disciplinary nature of the issues highlighted during the eruption, the IVATF adopted a project management approach and principally worked through four programme sub-groups (atmospheric sciences, airworthiness, and air traffic management, and another sub-group focused on IAVW coordination). More than 100 experts nominated by countries (States) and international organizations contributed depending on their particular area of expertise. The IVATF produced a significant number of recommendations, including furthering efforts to monitor volcanoes on the ground, improve eruption detection and measurement capability, improve knowledge and use of eruption source parameters, and collect and use relevant meteorological data.

Specifically, in regard to volcano observatory arrangements, the IVATF proposed amendments to internationally agreed guidance on services for International Air Navigation to ensure appropriate volcanic eruption monitoring, volcano observatory response and notification within the International Airways Volcano Watch (IAVW). In addition, the International Civil Aviation Organisation (ICAO) will be conducting, through Regional Offices and with the assistance of concerned Volcanic Ash Advisory Centres (VAACs), three Special Implementation Projects in 2012 (in the African, European, and Central American and Caribbean Regions) targeted at States which maintain volcano observatories to assist them in ensuring the effective implementation of the IAVW arrangements and associated ICAO provisions.

In June 2012, after four major meetings and intensive work by correspondence, the task force delivered its results and was dissolved. Further work will be carried out by other ICAO groups, and by the WMO IUGG Volcanic Ash Scientific Advisory Group. However, the active involvement of States and State Volcano Observatories in the global effort to build eruption observation and prediction capacity is critical to the success of these efforts.

First-order estimates of economic losses from ash fall for some Asian mega cities

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First approximation economic losses can be estimated by combining information about the probability of a hazard occurring, an inventory of exposed assets (and their values), and a series of functions indicating the vulnerabilities of the assets to the impact of the hazard. We use this approach to examine potential losses from ash fall in five Asian mega cities - Jakarta, Manila, Taipei, Tokyo, and Seoul.

Ash fall magnitude and frequency for the five mega cities were estimated by Jenkins et al. (2012) after utilising the ASHFALL tephra dispersal model to simulate 1000 scenario eruptions for each volcano threatening each of the five cities. Results are expressed as exceedance probabilities of ashfall thickness per square kilometre of city.

Exposure is estimated by dividing the areas of each city into broad land use types - commercial, industrial, residential, roadway, open space, airport etc. Per unit values are assigned to each land use type.

Vulnerability functions for a range of ashfall thicknesses relevant to each land use type have been developed. These functions also take into account the costs of ashfall cleanup and removal.

The methodology allows ranking of the cities in terms of ashfall risk and can be extended readily to other cities, to other assets, and to other natural perils.

Airborne in-situ measurement of Sakurajima volcanic ash plume with light aircrafts and optical particle counters

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It is clear that the no-fly zone of airplanes during a volcanic eruption has great influence on the economic activity in the respective area, based on the experience during the 2010 eruptions of Eyjafjallajokull in Iceland. When the extent of volcanic ash clouds is predicted from simulation calculations, the airspace may be closed. However, during the volcanic eruption of Iceland, European aviation authorities took the measure which loosens no-fly zone of an airplane according to the concentration of volcanic ash in order to avoid confusion of an air route at an early stage. In that case, the diffusion of volcanic ash clouds grasps viewing or a satellite photograph, and the concentration of volcanic ash is measured by LIDAR (detection by a laser picture) in the ground.

This research firstly aims at grasping the three-dimensional structure of volcanic ash plume by the in-situ airborne ash measurement. The atmospheric diffusion model which predicts the volcanic ash concentration is verified by the comparison between observed and calculated values. The in-situ field is Mt. Sakurajima in Kagoshima where the eruption frequency is high. Moreover, the possibility of usage of the X-band MP radar for measuring volcanic ash clouds is also investigated.

The volcanic ash dispersion of the Aira super-eruption, Japan

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The Aira (AT) caldera super-eruption in the Kyushu, southwest Japan was much important event in last 100 ka. In terms of eruption volume and dispersion map of the Aira super-eruption, it released at least 500 km^3 products and volcanic ashes were eastwardly dispersed to Honshu, Hokkaido and the Japan Sea at the downwind direction. The tephrostratigraphic studies of the Aira super-eruption have well done by other previous studies in the Japan area.

In the recent, a notable new discovery is that the volcanic glass shards of the Aira caldera super-eruption are found at the depth 2160 cm of the IMAGES MD052910 core (24°1.64'N; 122° 12.04'E) at the western offshore Taiwan. The SiO_2 and K_2O chemical compositions as well as $^{87}Sr/^{86}Sr$ and εNd isotopic ratios of glass shards in the core are 78.16%, 3.56%, 0.70630 and -4.1, respectively, which are completely consistent with those of the Aira super-eruption. Based on the C-14 dating results of MD052910, the sedimentary time of the depth 2160 cm can be estimated as 29.4 ka ^{14}C age BP, which is also consistent that the suggested age as 26-29 ka of the Aira super-eruption (Machida and Arai, 2003)

The volcanic ashes were dispersed almost the same order of distances at both down and up wind directions during the super-eruption. What kind of eruptive styles and how to disperse so far in the upwind direction become very interesting question. The similar manifestation of volcanic ash distribution of the Toba super-eruption has been found in not only Indian peninsula, but in the South China Sea. The results strongly suggested that the volcanic ash dispersed behaviors of the super-eruption should appear the more complicate mechanism of ash dispersion. Baines and Sparks (2005) claimed that the super-eruptions shall generate the giant 'spinning' ash clouds , which are greater than 600 km and up to 6000 km in diameter.

Polarimetric radar observations of volcanic eruptions

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There have been several reports of 'conventional' radar succeeded in detecting volcanic eruptions and estimating ash amount distributions. In addition to this information, 'polarimetric' radar has the potential to deduce the microphysical properties of volcanic ash particles such as ash particle size distribution, particle shape and postural. From analogy of past studies of hydrometeor classification in radar meteorology, polarimetric radar parameters may be used to discriminate ash particles from hydrometeors, which is a difficult task for non-polarimetric radar. The present study examines the potential use of polarimetric weather radar in the detection of volcanic eruptions, quantitative ash fall estimations (QAE), and the microphysical retrieval of ash particles.

The radar data analyzed in the present study are from the eruptions of the Mt. Shinmoedake volcano (1,421 m ASL) in the Kirishima Mountan Range and the Mt. Minamidake volcano (1,040 m ASL) in Sakura-jima, Kagoshima prefecture, both of which are located in southern Kyushu, Japan. The data selected for analysis are based on the Japan Meteorological Agency (JMA) monthly report on volcano activity, collected from 27 explosive eruptions of the Mt Shinmoedake volcano during the period January to March 2011, and 12 explosive eruptions of the Mt. Minamidake volcano during the period July to October 2012. The radar data from the Mt. Shinmoedake eruptions were collected by Kunimiyama C-band polarimetric radar, which was located 67.8 km south of the Mt. Shinmoedake volcano. The radar data from the Mt. Minamidake eruptions were collected by Tarumizu X-band polarimetric radar, which was located approximately 11 km south-southeast of the volcano.

Based on analysis of the eruption time period, the maximum and accumulated reflectivity factor, and the differential reflectivity of the volcanic ash, we reach the following conclusions:

1) Operational polarimetric weather radar has the potential ability to quantitatively estimate the amount of volcanic ash expelled during volcanic eruptions.

2) The *Z*-*A* relationship, where *Z* is reflectivity and *A* is the ash amount, can be derived if ground measurements of the ash amounts are available.

3) The coefficient and exponent of the power low function of the *Z*-*A* relationship is dependent on each volcanic eruption, which may be due to the difference in ash particle size distribution.

4) Differential reflectivity over a volcano crater fluctuates in space and time, while showing significant spatiotemporal patterning in the downwind regions, which suggests the presence of an ash particle aggregation and sorting mechanism.

5) The radar cannot detect weak ash echoes due to the minimum detectable reflectivity, which depends on the range from the radar and the receiver noise level of the radar system.

6) In-situ measurements of ash particles are necessary for more detailed analyses of polarimetric radar parameters.

Review of past aircraft volcanic ash encounters in Japanese airspace involving international airlines

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Volcanic ash encounters by large transport airctaft were reported in this country, especially at Kasgoshima Airport area, since 1970s. Kagoshima Airport and its approaching and departing route are located in the proximity of Sakurajima Volcano, less than 20km at closest point. Coutermeasures against ash encounter in this area have improved by reflecting past experience of encounters based on cooperations of government agencies and airlines, and contributions by academic group such as Sakurajima Volcanological Observtory, Kyoto University.

On the other hand, at other volcanos in this country, volcanic ash encounters were reported in recent years since 1990, e.g.,at Unzen Volcano in 1991 and at Miyakejima Volcano in 2000. Post incident investigation of respective volcanic ash encounter should be carried out carefully to find out cause of encounter correctly and accurately in order to reflect them properly to countermeasures against future encounters.

Since mid 1990s, ICAO VAACs have been established and they have been working hard and contributed to prevention of volcanic ash encounters in the world. However, VAAC is not a final goal of countermeasures for prevention of volcanic ash encounters.

The aircraft encounter case with volcanic ash of Unzen Volcano on 27 June 1991 was reviewed by the author and was concluded that the reported items in this case was not conssitent with volcanic activities of the volcano on this day including previous day. It was more likely to be associated with the "High Altitude Ice Crystal Icing" reported by Mason(2007), rather than volcanic ash encounter. There is not direct evidence to proove the case at this stage due to 20 years of time has gone already, but it should be further studied from aviation meteorological point of view in stead of volcanoclogical point of view.

The B747 and B737 encounter with Miyakejima volcanic ash on 18 August 2000 was researched with supplementing new stuffs recorded at the time of ash encounter. The results did not agree with some past reports on the case. The area was adjacent to terminal area of Haneda Airport and Narita Airport and have heavy air traffic in the proximity of active volcanos. Countermeasures for this area shall be discussed.

Investigation of the impacts of volcanic eruption on flight passengers and cargo: A case study of Sakurajima volcano

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In recent years, transportation modes for passengers are becoming more diversified due to new developments of transportation systems. For example, a new trunk rail line between Hakata Station and Kagoshimachuo Station was constructed in 2011. As a result, entire Kyushu Shinkansen was completed, which leads to 4 hours or less for the trip between Shin-Osaka station and Kagoshimachuo station. In addition, the low-cost carriers are launched into service in recent years, attracting the passengers who require both time and cost reductions. Passengers can choose transportation of several modes for going to the destination depending on the situation.

If airports are closed by natural disasters or accidents, passengers and cargo flows have to be redirected or stopped otherwise. As a result, the change may induce significant economic losses. In fact, there were the cases that large amount of economic damages were caused by closures of airports due to volcano eruptions. Eyjafjallajokull volcano in Iceland corresponds to such a case. This eruption caused confusions of society in a large area, since many airports in Europe were forced to be closed by visible and invisible ash in the air. According to the International Air Transport Association, the airline's loss was estimated as $ 200 million per day.

In order to properly assess the risk of such an event, this study proposes a method to analyze changes in the flow of passengers and cargo in the situation when the airport was disrupted due to a volcanic activity. Eruptions of Sakurajima volcano in Kagoshima Prefecture is selected as a case study. One of the features of the focuses in this study is that the restrictions of flights change from day to day depending on the conditions such as wind and volcanic activities. Therefore, it is necessary to dynamically represent the flight restricted area and to analyze the change in the modes of transportation. In addition, this study uses the method for selecting the Kth best path to reduce the computation time of implementing the dynamic model The usefulness of the model is demonstrated through the case study.

Measurements and mapping of volcanic plumes with light aircraft, examples of research flights during eruptions of Eyjafjallajoekull, Grimsvoetn and Etna

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Volcanic eruptions can pose a considerable threat to aviation. This became evident by the airspace closures during the eruptions of Eyjafjallajoekull 2010 and Grimsvoetn 2011 and interim closures of the airport Catania after paroxysmal eruptions of Etna 2011. In these situations the Laboratory of Environmental Measurement Techniques (LEMT) of the Duesseldorf University of Applied Sciences and the Earthquake Engineering Research Institute (EERI) of the University of Iceland used light aircrafts, equipped with optical particle counters (OPCs) and partly with volcanic gas measurement systems, for exploring the volcanic plumes and for plume mapping.

During the eruption of the Eyjafjallajoekull 2010 LEMT performed 14 research flights over North Germany. The results of these flights were compared with the model calculations of the London VAAC. In parallel EERI performed measurement flights over western Iceland. During two of these flights the outskirts of the ash plume were entered directly by the aircraft delivering concentrations of about 2000 micro g/m3. In Germany the Eyjafjallajoekull ash plume appeared to be strongly structured in horizontal and vertical direction during the flights. Peak concentrations of up to 330 micro g/m3 could be found.

During the Grimsvoetn eruption 2011 LEMT and EERI performed several cooperative measurement flights over Iceland and northern Germany. A part of the flights on Iceland was performed officially for the Icelandic flight operator ISAVIA. The aircraft measurements in the region over Keflavik and Reykjavik revealed mostly small ash concentrations in contrast to the predictions of the VAAC dispersion model.

Therefore these aircraft measurements helped to re-open the international airport of Keflavik by ISAVIA. In a similar way aircraft measurements over northern Germany on 25 May 2011, which were performed by LEMT for the German Weather Service DWD, showed low ash concentrations over northern Germany, despite of high predicted VAAC model calculations. Therefore the re-opening of the German airports Hamburg, Bremen and Berlin was in accordance with the low measured ash concentrations by the LEMT aircraft.

Moreover this light aircraft was used by LEMT for studies of the volcanic plumes of Etna in 2011 and enabled the determination of SO2 fluxes.

In general light piston-motor driven aircraft proved to be robust enough to operate even at elevated ash concentrations. Because these aircraft are able to fly at low cruising velocities during measurements they can deliver spatial high resolution results. Moreover, the OPCs of these aircraft were calibrated in a special dust/wind tunnel with volcanic ash, thus delivering ash concentration results with high accuracy.

It is important to note, that the LEMT aircraft is on official standby now for the German Weather Service DWD and the German Transport Ministry for official airborne measurements in Germany in case of another volcanic eruption.

Sakurajima volcano: a physico-chemical study of the health consequences of long-term exposure to volcanic ash

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Regular eruptions from Sakurajima volcano, Japan, repeatedly cover local urban areas with volcanic ash. The frequency of exposure of local populations to the ash led to substantial concerns about possible respiratory health hazards, resulting in many epidemiological and toxicological studies being carried out in the 1980s. However, very few mineralogical data were available for determination of whether the ash was sufficiently fine to present a respiratory hazard. In this study, we review the existing studies and carry out mineralogical, geochemical and toxicological analyses to address whether the ash from Sakurajima has the potential to cause respiratory health problems. The results show that the amount of respirable (less than 4 micron.) material produced by the volcano is highly variable in different eruptions (1.1 to 18.8 vol. per cent). The finest samples derive from historical, plinian eruptions butconsiderable amounts of respirable material were also produced from the most recent vulcanian eruptive phase (since 1955). The amount of cristobalite, a crystalline silica polymorph which has the potential to cause chronic respiratory diseases, is 3 to 5 wt. per cent in the bulk ash. Scanning electron microscope and transmission electron microscope imaging showed no fibrous particles similar to asbestos particles. Surface reactivity tests showed that the ash did not produce significant amounts of highly reactive hydroxyl radicals (0.09 to 1.35 micro mol/m2 at 30 min.) in comparison to other volcanic ash types. A basic toxicology assay to assess the ability of ash to rupture the membrane of red blood cells showed low propensity for haemolysis. The findings suggest that the potential health hazard of the ash is low, but exposure and respiratory conditions should still be monitored given the high frequency and durations of exposure.

Radon levels due to volcanic activities of Mt. Sakurajima

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The high polonium-210 concentrations from Mt. Sakurajima volcano have been observed on 1980s. Polonium-210 is generated from radon-222 by radioactive decay. The radon-222 concentration may also be possibly high when the high polonium-210 concentration was observed. The WHO proposed a reference level of indoor radon gas ranging from 100 to 300 Bq m-3, and its inhalation is supposed to increase the risk of lung cancer after tobacco smoking. Radon is generated from soil, rocks, groundwater, and building materials. These soil and rocks can be regarded as the main source. Recently, number of eruption of Mt. Sakurajima is increasing. The aim of our present study is to clarify the relationship between Mt. Sakurajima volcano activity and radon-222 concentration in the environment. The outdoor radon-222 concentration has been measured by pulse-type ionization chamber in Tarumizu City, Kagoshima located at approximately 10 km south-southwest of Mt. Sakurajima. Continuous measurements of radon concentration were performed from Sep., 2008 to Feb., 2010 and from Aug.,2012 to Nov., 2012. Meteorological data such as temperature, humidity, atmospheric pressure, wind speed and precipitation were also observed. A passive integrated radon-thoron discriminative detector is used for measuring indoor and outdoor radon concentrations in dwellings. In the present study, not only these results but also other important parameters such as radon flux density, ambient dose rate and natural radionuclide concentrations, which have a potential relation with outdoor radon concentration around the measured sites are shown.

Evolution in phase composition and morphology of volcanic aerosols during transport: the Eyjafjallajoekull plume 2010

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To assess the impacts of volcanic aerosol on the environment and anthropogenic activity, the physico-chemical properties of the particles have to be known. Such information is usually drawn from samples taken on the ground or indirectly from remote sensing. Ground samples reflect only a deposited fraction of the aerosol. Remote sensing allows to extract grain size distribution of an volcanic aerosol assuming monophasic, spherical aerosol particles. Ash dispersal models are also based on same assumptions. Volcanic aerosols, however, are usually composed of more than one phase, each with a distinct density and preferred shape. In general, the main components are glass particles, phaenocrysts of minerals, which have crystallized before the eruption occurred, particles, which are formed through resublimation of volatile components, and externally mixed particles composed of the previous components. Particles of same size may have different travel distances because of differences in density and/or shape. During transport, therefore, not only the average size of particles but also the phase composition and the morphological character of a volcanic aerosol will change.

When assessing the societal and environmental impact of a volcanic plume these continuous physico-chemical changes will ultimately have to be taken into account. The eruption of Eyjafjallajoekull 2010 and the entrainment of its plume into European airspace gave the possibility to sample a volcanic aerosol after several thousands of kilometers of transport both in the air and on the ground. We compared the mineralogical composition and the morphology of particles of the following samples: 1) collected from an air filter of a piston- engined plane, which entered the plume close to the crater, 2) resuspended particles sampled at 20 km from Eyjafjallajoekull, and 3) taken from an airplane, which crossed the plume over the Dutch-German border. A clear change in mineralogy and morphology could be observed. The airborne samples sampled in Europe are impoverished in phaenocrysts. This reflects most probably the difference in density between the volcanic glass and the phaenocrysts. The aspect ratio of the particles evolves also during the transport. Particles with high aspect ratio are almost absent in the plume over Europe. Possible explanation is the higher specific surface of such particles, which will enhance the tendency of aggregation. The average physical properties of the aerosol thus changes with transport. The average hardness of the aerosol, important to assess the mechanical impact on airplane components, decreases with transport. Particles with high melting points e.g. olivine and pyroxene phaenocrysts are also decreasing in concentration with transport.

A new tool for assessing the hazards from leachable elements in volcanic ash

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Volcanic eruptions can produce a wide range of hazards. Although volcanic phenomena such as pyroclastic density currents and surges, sector collapses, lahars and ballistic blocks are the most destructive and dangerous, volcanic ash is the most widely distributed eruption product and the most likely to be encountered by the public. Following an eruption, the public, civil authorities and agricultural producers will have major concerns about the effects of ashfall on human and animal health, drinking water supplies, crops, soils and surface runoff. Freshly-erupted ash contains a range of potentially toxic soluble elements, which may be released either rapidly or more slowly upon contact with water or body fluids.

As part of the immediate emergency response, there should be rapid dissemination of information about the physical and chemical properties of the ash and its hazardous potential. However, there is a wide range of chemical components that can be tested for, which can lead to confusion about whether a health threat exists or not. To address this uncertainty, an international working group has recently developed a protocol for the analysis of volcanic ash samples to assess the hazard from leachable elements. The purpose of this protocol is to recommend clear, standard and reliable methods for the rapid assessment of hazards from leachable elements. The four applications developed to date are: a general purpose water leach, relevant to assessing impacts on drinking water supplies, livestock drinking water and availability of soluble elements for plant uptake; assessing ingestion hazards to livestock; assessing ingestion hazards to humans; and assessing respiratory inhalation hazards to humans. The adoption of standardised methods should improve and facilitate the comparability of results among different studies and enable the ongoing development of a global database of leachate information relevant for informing improved volcanic health hazards assessment.

This presentation will outline the new protocol and describe its application to recent eruptions (4 June 2011 eruption of Puyehue-Cordon Caulle volcanic complex, Chile; and 6 August 2012 eruption of Mt Tongariro, New Zealand).

Assessing tephra impacts on agricultural systems: the case for standardisation of an analysis protocol

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Agricultural systems can be vulnerable to the physical and chemical impacts of tephra deposition. Accurate impact assessment is needed to identify potential losses and provide support for farmers immediately after the eruption and over the longer recovery period. Previous tephra fall events have shown that it is important to understand the physical and chemical characteristics of the tephra, soil and depositional environment. Climatic conditions may also be important in determining the impacts of tephra fall on agricultural systems. Data from previous events has shown that agricultural losses have been predominantly due to the physical nature of the tephra, except in instances where tephra has contained elevated concentrations of fluoride. To date some impact assessment studies have included different analytical protocols to chemically and physically analyse tephra, leading to issues with the comparison and interpretation of results across different industry and infrastructure groups and tephra fall events. A standard set of methods for testing agricultural land and assessing the impacts after tephra fall is needed. We are developing a standard analysis protocol using information from previous impact assessments and laboratory experiments. This protocol will identify the tephra and soil properties and any climatic characteristics that need to be quantified and the most accurate methods to use. The creation of a standard protocol will streamline the analysis process and provide greater comparative and transparent analysis of results for each tephra fall and between different tephra falls. This will enhance stakeholder's ability to decide the most effective mitigation strategies.

Health effects of volcanic activities of Mt. Sakurajima

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Mt. Sakurajima in Kagoshima, Japan is located close to metropolitan areas, and is one of the most active volcano in the world. At the time of a large eruption in 1914, lave discharged by the volcano connected the Island of Mt. Sakurajima to the Ohsumi Peninsula. Since then, it has become active every 10-30 years. Relatively active periods were around 1935, 1946, 1956-67, and the period between 1972 and 2001 with it peak in 1985. In recent years, it has become active again and, in 2011, it erupted more than 1000 times a year. In 2012, the number of eruptions decreased but still it erupted nearly 1000 times a year. Mt Sakurajima disgorges various dusts and gases, including sulfur dioxide, silica and radon gases. This paper, which is to be presented at the session on various volcanic activities and their health consequences of major volcanoes in Japan, will review studies of the chronic health effects of the volcanic activities of Mt. Sakurajima, including our recent study, which showed an increase of lung cancer in the vicinity of this volcano.

Therapeutic and health promoting effects of rehabilitation with balneotherapy

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Balneotherapy for patients with disabilities is one of the oldest forms of rehabilitative therapy. Balneotherapy includes several modalities of treatments and wellness programs, such as physiological and pharmacological effects of warm water bathing and aqua-exercise, relaxing and biorhythm adjusting effects of staying in the urban climates and educational instruction for healthier life style. In order to examine the effects of balneotherapy for patients with disabilities, our rehabilitation methods in combination with balneotherapy were reviewed. 1) Effects of warm water bathing of hemiplegic lower limb on its isokinetic muscle strength were studied in twelve chronic stroke patients (53.3 +/- 14.2 y.o.). Peak torque of the knee flexions at any velocity increased after warm water bathing. Change in the maximum power and total work were similar to that of the peak torque. Warm water bathing might make it easy to exert their muscle strength at l20 degrees/sec in flexion corresponding to their severity of their hemiplegia. 2) Nine hemiplegic patients participated in the second study (56.9 +/- 16.6 y.o.). Participants sat in a relaxed position on a chair, and dipped the affected forearms into warm water at 40 degrees C for 15 minutes. After forearm bathing, the simple test for evaluating hand function score increased significantly, the resistance power of elbow extension at 90 degrees/min decreased significantly. Forearm bathing appeared to improve function and decrease spasticity in hemiplegic hands. This treatment might facilitate hand rehabilitation. 3) The aim of third study is to assess the efficacy of exercise baths on quality of life (QOL). 49 subjects (20 patients with brain disease, 21 patients with orthopedic disease, and 8 patients with other diseases) were first treated by conventional rehabilitation comprising physical therapy and occupational therapy for 4.2 +/- 1.4 weeks. Exercise baths were then added to the rehabilitation program for a further 4.4 +/- 1.2 weeks. QOL was evaluated by alterations in the MOS Short-Form 36-item Health Survey (SF-36). We defined the period from admission to exercise bath start as Treatment I, and the period from exercise bath start to discharge as Treatment II. On admission, before and after exercise bath, QOL was evaluated using the SF-36 scores. We found that the increase of all eight subscales of the SF-36 was smaller in Treatment I period than in Treatment II period. It was concluded that exercise baths are an effective non-pharmacological treatment that might facilitate rehabilitation programs.

We observed beneficial effects of balneotherapy on controlling the spasticity of hemiparetic limb, in accomplishing repetitive facilitation exercise that strengthen neural circuits, and on the quality of life in patients with stroke and orthopedic patients. Rehabilitative treatment in associated with both neuro-rehabilitation and traditional spa therapy will develop and contribute to welfares of the people.

Prognosis for survival in burns victims rescued from dilute pyroclastic density currents at Merapi volcano, Indonesia

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Clinical details of 106 burns victims who survived to reach hospital in three lethal eruptions of Merapi on 22 November 1994, 26 October and 5 November 2010 were available for analysis of the probability of surviving their injuries using age, sex and burn extent (% total body surface area).as prognostic indicators. In the 1994 eruption, 63 reached the Dr Sardjito Hospital, Yogyakarta, of whom 19 survived to leave hospital. In 2010, 43 were hospitalized with only 4 survivors in the 26 October event and 18 survivors on 5 November; all were treated in the Sardjito Hospital. The maximum PDC temperatures at the three eruptive events which occurred on the south flank of Merapi were in the same range (200-300℃) and the distance (time) to hospital was similar. The 106 victims were matched with burns victims in the UK national burns database. The most accurate matches of the patients were with grouped data in the revised Baux Index, the Abbreviated Burn Severity Index, and the Belgian Outcomes Burn Index. These results suggest a more favourable prognosis of severe burns in PDC victims than expected.

Future Icelandic eruptions and their potential health impacts in Europe

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The six-week eruption of Eyjafjallajökull volcano in 2010 restored Icelandic volcanoes to the UK government risk register and raised new interest in the respiratory health impacts of active volcanism affecting European populations. Concern surrounds the future possibility of a larger Icelandic ash eruption with a longer duration which might have immediate respiratory health effects and also raise questions about potential chronic health risks and the preventative measures that would need to be considered. Of prime interest is the widespread air pollution caused by fine particulate matter (PM10, PM2.5 and nano-particles), as well as sulphate aerosol, and whether the toxicity of volcanic particles is comparable to that of particles from traffic emissions in urban air. A future eruption on the scale of the Laki fissure in 1783 could potentially add sulphur dioxide to this list. This presentation will review the collaborative work with volcanologists and other scientists that is currently underway to answer these questions, including a review of the respiratory health impacts of Laki in 1783.

What if a Laki-type eruption were to happen tomorrow?

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The eruptions of Eyjafjallajökull in 2010 and Grímsvötn in 2011 in Iceland not only alerted European governments to the risks posed by volcanic ash but also to those that could arise from so-called low-probability, high-impact sulfur-dominated volcanic events such as the 1783-1784 CE Laki eruption (Iceland).

Historical records show that the Laki eruption caused severe environmental stress and posed a health hazard far beyond the borders of Iceland [1]. Given the reasonable likelihood of such an event recurring, it is important to assess the scale on which a future eruption could impact society. We quantify the potential health effects caused by an increase in air pollution during a future Laki-type eruption using an advanced global aerosol model (GLOMAP) together with concentration-response functions derived from modern epidemiological studies.

The concentration of particulate matter with diameters smaller than 2.5 micrometers (PM2.5) is predicted to double across central, western and northern Europe during the first three months of the eruption. Over land areas of Europe, the current World Health Organization 24-hour air quality guideline for PM2.5 is exceeded on an additional 36 days on average (range 13-63 days) over the course of the eruption. Based on the changes in particulate air pollution we estimate that between 139,000 and 144,000 additional cardiopulmonary fatalities could occur in Europe depending on the meteorological conditions [2]. Such a volcanic air pollution event would therefore be a severe health hazard, increasing excess mortality in Europe on a scale that likely exceeds excess mortality due to seasonal influenza.

We will also discuss hazard mitigation and response strategies as well as the challenges encountered when aiming to quantify the potential health hazards posed by a long-lasting volcanic event in Iceland.

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Volcanic health hazard: the acidification of seawater and trace metals accumulation study in Blue Mussels (Mytilus galloprovincialis). Vulcano Island (Italy)

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Mussels are considered to be heavy metals bio-accumulators and, at least in coastal areas, represent a significant part of the humans diet. Due to the fact that such animals could be breeding in active volcanic areas interested by acidification of seawater and increased mobility of heavy metals, the consumption of mussels could represent a hazard for human health.

Acidification of seawater is due to the presence of submarine vents releasing abundant volcanic CO2-rich fluids. In aquatic system gaseus CO2 dissolves and, hydrates to form weak carbonic acid, which is the main driver of natural weathering reactions. The result of the CO2 increase is seawater acidification.

Vulcano Island, the southernmost of Aeolian Islands, is located in the Southern Tyrrhenian Sea (Italy), approximately 18 miles off the NE coast of Sicily. Four geochemical surveys of the Levante Bay were carried out in April - September 2011 and May - June 2012. The main physico-chemical parameters (T, pH, Eh, electric conductivity) were measured at more than 70 sites and more than 40 samples for chemical analyses were collected at representative points. Major and trace elements dissolved in water, the chemical composition of dissolved gases (He, H2, O2, N2, CH4 and CO2) and the isotopic composition of total dissolved inorganic carbon were determined in the laboratory.

The bubbling CO2 produces a strong decrease in pH from the normal seawater value of 8.2 down to 5.5. In the area close to the main degassing vents, characterized by very low pH, macroorganisms are absent. Further north in the bay, about 300 m from the main vents the pH of seawater is only slightly lower than normal ocean waters (pH 8.2 - 7.8) resembling conditions in equilibrium with the high atmospheric CO2 concentrations expected in the near future up to the end of the century. Therefore environments like these, naturally enriched in CO2, are good laboratories to study the consequences of ocean acidification on aquatic biota. Furthermore acidification is tightly linked with the mobility and bio-availability of heavy metals in sea water.

A Blue Mussels transplant experiment was done along the pH gradient in order to estimate the accumulation capability in relationship with acidification of seawater. At the end of the experiment the mussels showed an increase of concentration for some elements such as (Fe, As, Mo, V and Pb) with respect to blanks.

The present study provides important information about the best environmental management of active volcanic areas such as Vulcano Island.

New results and review of major and trace element output from worldwide passive degassing volcanoes

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Volcanic emissions represent one of the most important natural sources of trace elements into the atmosphere (e.g. As, Cd, Cu, Hg, Pb, Sb, Tl and Zn), sequentially influencing the other geochemical spheres (hydrosphere, lithosphere and biosphere). The human health hazard during episodic volcanic eruptions due to coarse and fine particles (2.5-10 and <2.5 μm) fall out like asthma and lung and respiratory disease is well documented. Regarding passive degassing volcanoes, the harmful effect of fluorine fumigation are known both for vegetation (foliar necrosis) and human/animals (fluorosis), but only few study have been focused on the effects of potentially toxic trace elements. From a literature review on metals output from active worldwide volcanoes, we found 37 publications (the first dating back to the 70's), 13 of which relate to the Etna and the other include some of the world's most active volcanoes: Mt. St. Helens, Stromboli, Vulcano, Erebus, Merapi, White Island, Kilauea, Popocatepetl, Galeras, Indonesian arc, Satasuma and Masaya. In general, the review shows that currently there are very few data available. We compiled a database both for concentrations and fluxes of 59 chemical elements (major and trace), that allow us to define the compositional and output range. In this study we present unpublished results from Etna (Italy), Turrialba (Costarica), Nyiragongo (Democratic Republic of Congo), Mutnovsky and Gorely (Kamchatka), Aso Asama and Oyama (Japan). Concentrations of major and trace elements were obtained by direct sampling of volcanic gases and aerosols on filters. Sulfur and halogens were collected by using filter-packs methodology, and analyzed by ion chromatography. Untreated filters for particulate were acid digested and analyzed by ICP-OES and ICP-MS. Sulfur to trace element ratios were related to sulfur fluxes to indirectly estimate elementar fluxes. Etna confirms to be one of the greatest point sources in the world. The Nyiragongo results to be also a significant source of metals to the atmosphere, especially considering its persistent state of degassing from the lava lake. Also Turrialba and Gorely have high emission rates of trace metals considering the global range. Only Mutnovsky volcano show values which are sometimes lower than the range obtained from the review, consistent with the fact that it is mainly a fumarolic field. The accurate estimation of individual and global volcanic emissions of trace metals is still affected by a high level of uncertainty. The latter depends on the large variability in the emission of the different volcanoes, and on their changing stage of activity. Moreover, only few of the potential sources in the world have been directly measured. This preliminary work highlights the need to expand the current dataset including many other active volcanoes for a better constraint of global trace metal fluxes from active volcanoes.

Groundbased in-situ particle measurements in the nearfield of Grimsvoetn volcano, Iceland 2011

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During the eruption period of Grimsvoetn volcano, a series of particle measurements where performed in the direct near field of the eruption event. Two fixed monitoring stations in the south of Iceland (south westerly of the eruption event) are established to discriminate continuously the plume dispersion. Both stations in Skogar and Hvolsvollur are approximately 150km linear away from the eruption event at two significant positions.

In situ particle characteristics were measured using a Grimm 107 optical particle counter (OPC). The OPCs were able to detect particles in a size range between 0.25- 32 micron in 31 classes. By converting of the particle size distribution with a refractive index correction a more detailled size distribution can be calculated.
The number concentrations, delivered by the OPCs, were converted to mass concentrations for TSP (Total Suspended Particles), PM10, PM2.5 and PM1 which are important for limit values.

To characterize the measured particles, they were collected to filters for study the optical and chemical properties. The results show the propagation of the particles and their changes of the size distribution during the eruption event. The chemical property of the particles from this eruption event varies to the particles of the Eyjafjallajoekull.

Volcanic ash hazard assessment In West Java, Indonesia using FALL3D computational model

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Indonesia, a country with many active volcanoes, has experienced a great loss of life . Approximately 100,000 casualties had passed away over the past 200 years due to volcanic eruptions. It is featured by the highest frequency of eruption magnitude of VEI 4 or larger during historical time. One of the eruption material produced during eruption is volcanic ash.

Volcanic ash is the most widespread of all volcanic hazards and has the potential to adversely affect millions of people in the densely populated islands of the Asia Pacific region. Volcanic ash represents a serious hazard to many towns, cities and megacities (population in excess of 10 million) in the vicinity of active volcanoes in developing countries like Indonesia. Undertaking volcanic ash fallout hazard assessments is an important scientific, economic and political exercise and of great importance to public safety, especially for communities on the many densely populated islands of Indonesia.

No detailed information available for this region on the hazard threaten by volcanic ash from volcanoes that have not erupted in recent times in particular. Therefore a clear need exists for computational models capable of accurately predicting volcanic ash dispersal at ground level when coupled with field observations of historical or on-going eruptive activity. The validation of the FALL3D has been nicely done in two volcanoes, Guntur and Tambora volcanoes.

Modelling volcanic ash in four volcanoes in West Java (Gede, Guntur, Galunggung, and Ciremai) using computational model FALL3D (an ADS model) as useful tool for assessing volcanic ash hazard. The parameters employed in this modelling include grain size, density, and sphericity analyses combined with assume eruption column heights (based on historical eruptions) as volcanological inputs along with topographical terrain data using DEM, and meteorological input data.

We present volcanic ash hazard assessments and their impacts using deterministic and probabilistic approach. In addition we model as well, predictive scenarios of ash load on the ground and ash concentration in the atmosphere at some flight levels in the context of aviation safety.

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Using MODIS images for the monitoring of volcanic clouds of Mexican volcanoes (Volcan de Colima and Popocatepetl)

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Mexico has two eruptive volcanoes since the early 90's: Popocatepetl and Colima volcanoes. They are surrounded by cities, towns and villages, which are periodically being affected by ash fall and the impact on air quality due to the presence of SO2. Besides, the aviation industry is also affected by the presence of ash and gases in the atmosphere and the bulk deposition in its installations. In the case of Popocatepetl volcano a total of 120 airways cross the volcanic clouds influnce area within 200 NM radius with an average of 388,000 annual operations. In a similar area, at Colima Airport a total of 106 airways are affected by the volcanic clouds with an annual average of 84,000 operations. On the ground, 21 airports do exist around Popocatepetl and 13 in the case of the Colima volcano.

For this reason, the implementation of monitoring techniques of these volcanoes is of crucial importance for both, risk mitigation at nearby towns as well as warning for aviation operations that could be affected. Remote sensing from satellite platforms are very useful tools. MODIS images has several advantages due to the wide spectrum of detection with MODIS (36 bands), which allows to identify and monitor volcanic ash and SO2. Moreover, MODIS has a time resolution of up to 4 frames per day because of the existence of two satellites with MODIS sensors (TERRA-I and AQUA-I).

This study shows the advances reached in the implementation of a monitoring methodology based on MODIS for observing the Mexican volcanoes under eruption.

Automatic program of the detection of ash plume and estimation its height using local seismicity

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Assessing volcanic hazards using remote methods, regardless of weather condition and the presence of observers, remains rather critical today, especially for flight safety. Seismicity has long been one of the most commonly monitored aspects of active volcanoes because of its 24 hours per day reliability regardless of weather. Kamchatkan Branch of Geophysical Survey RAS began to use an original empirical method for detecting ash plumes and estimating plume heights using local seismicity in 2003. We collected many video, photo and visual data of ash plumes. Our database includes the ash plumes and corresponding seismic signals for four active volcanoes in Kamchatka. Sheveluch data includes more than 350 events, Karymsky data is more than100, Kizimen data is more than 20, Bezymianny data is 9. To detect seismic signals, corresponding to ash plumes, we use a program (author is Dmitry Droznin), which allows us to study a spectral of seismic signal and to calculate the integral of absolute ground velocity for ash plume height estimation. Since June 2012 our laboratory began to use the automatic program (author is Vitaly Bliznezov) to detect ash plumes from seismic data, which run every 15 minutes. This program uses the seismic signal amplitudes after application of band-pass filters and calculates the frequency index FI. FI is equal of decimal logarithm of the ratio the amplitude of high frequency band to the amplitude of low frequency band. This index FI allows to detect 75 percent of all ash plumes. Height H of ash plume is estimated from H=K*FI*(A*lnA - A), where K is the coefficient, FI is the frequency index, A is amplitude of signal, lnA is natural logarithm of the ratio of the amplitudes of any two successive peaks. Retrospective analysis of the ash plumes of Sheveluch allowed to estimate the coefficient of correlation between real observed by video system height of plume and the height calculated by the program. The coefficient of correlation is equal 0.69 for 240 events, which were registered by video observation since 2007. The use of this program in real-time monitoring allowed to detect and to estimate correctly new strong explosive eruptions of Bezymianny volcano on September 01, 2012, and of Plosky Tolbachik volcano on November 27, 2012. Now this program controls the explosive events of active volcanoes (Sheveluch, Bezymianny, Plosky Tolbachik, Kizimen, Karymsky) and send the messages to laboratory staff by email every 15 minutes. If an estimated ash plume height is more than 3500 m above sea level, programm send special message.

Effects of SO_2 on the respiratory system in Miyakejima residents seven years after returning to the island

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Background: Miyakejima Island is an island volcano 8 km in diameter, located 180 km south-southwest of Tokyo. In the last 500 years, Mt. Oyama has erupted repeatedly every 50 years. The last eruption started in June, 2000, and due to continuous eruptions and emissions of lethal/unsafe amounts of volcanic gas, the Miyake village government decided to evacuate all the citizens from the island in September, 2000. At the time of the evacuation, the amount of discharge of sulfur dioxide (SO_2), the major toxic component of the volcanic gas, was 50,000 tons/day. The volcanic activity gradually decreased, but it has not ceased, and SO_2 discharge of 400 - 700 tons/day continues to be observed as of January, 2013. In February, 2005, citizens began to return to live on the island despite the fact that volcanic gas was still being emitted.

Objectives: In this study, the health effects of exposure to the environment on Miyakejima Island following the lifting of the evacuation order in February, 2005, were investigated, first in February, 2006, and then in each November from 2006 to 2011. The relationship between the amount of exposure to SO_2 and health effects was studied in Miyakejima residents.

Method: The subjects of this study were registered residents of Miyakejima. A total of 4,089 check-ups for adults and 1,005 check-ups for children were conducted. The mean values and percentages hourly values of 0.10 ppm or more were obtained from 81 months of exposure concentration data obtained by fixed-point monitoring. Based on these values, we used averages to categorize the inhabited area into 1 lower-SO_2 area and 2 higher-SO_2 areas, namely, the Izu and Kamitsuki districts, referred to as Area L, the Igaya and Tsubota districts, referred to as Area H-1, and the Ako district, referred to as Area H-2. Health effects were evaluated through pulmonary function tests.

Results: The average SO_2 concentrations in Areas L, H-1, and H-2 were 4.57, 18.9, and 26.1 ppb, respectively. The rates at which the one-hour average SO_2 concentrations exceeded 0.1 ppm in Areas L, H-1, and H-2 were 1.35, 4.16, and 5.80 %, respectively. The Air Quality Standard of SO_2 in Japan is 0.04 ppm or below for the daily average of one-hour SO_2 concentrations and 0.1 ppm or below for the one-hour SO_2 concentration. The island as a whole has not yet achieved the standard.

In adult Miyakejima residents, there were significant differences in the %FVC and %FEV1 values observed in a comparison of pulmonary function by area. However, no significant difference was observed in a comparison over time. By contrast, children showed no reduction in lung function.

Conclusions: Follow-up observation should be continued with a focus on the relationship between the amount of exposure to SO_2 and health effects until the volcanic gas emissions have ceased.

The present state of Miyakejima SO_2 Gas Emissions and its Influence to Local Communities

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We will present an overview on the present state of volcanic gas emissions from Miyakejima volcano, Japan and its influences to the surrounding local communities. Miyakejima volcano has been emitting volcanic gas including poisonous sulfur dioxide from the summit caldera since the eruptions in 2000. The peak value of the SO_2 emissions exceeded 70,000 tons per day in November 2000 and the SO_2 concentrations more than 5ppm were often observed in the residential area in Miyakejima island at that time. This forced all of the 3800 residents to leave the island during September 2000 and February 2005. The SO_2 emissions are gradually decreasing and now they seldom exceed 1,000 tons per day. The concentrations more than 2ppm is observed only 9 times at observation sites in the residential area in 2012. At present, approximately 2800 people live in the island with careful monitoring of their health conditions as well as the observations of environmental SO_2 concentrations.

Clinical influences of an inhalation of volcanic ash from the massive eruption of Mt. Shinmoedake in patients with obstructive lung disease

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Background and objective:

It is controversial whether an inhalation of volcanic ash influences the control of chronic respiratory disease. We evaluated physiological effects of an inhalation of the volcanic ash in patients with obstructive lung disease, during the 2011 massive eruption of Mt. Shinmoedake, which is in the south part of the Kyushu island, Japan.

Methods:

The study was conducted as a cross-sectional analysis in adult patients with obstructive lung disease who lives in the foot area of Mt. Shinmoedake, and the far area from the volcano. All participants, who visited the enrolled medical institution on the day of the survey, filled out a self-reported questionnaire concerning about respiratory symptoms, CES-D, which measures depressive symptoms, SF-8, which measures quality of life (QOL), and patients' characteristics such as address, sex, age, smoking status, and the average daily time of outdoor activity after the eruption. Spirometry was performed after the questionnaire. The enrolled patients were classified into two groups, which are the high or low ash exposured group, according to the average time of daily outdoor activity after the eruption. Clinical or physiological parameters were compared between both groups.

Results:

One hundred-one patients (78 patients in the foot area and 23 patients in the far area) participated in this study. Forty-six patients (45.5%) experienced exacerbation of any one of the respiratory symptoms after the explosive volcanic eruption. In particular, approximately 30% of the participants complained of exacerbation of cough. No statistical differences of the respiratory symptoms were observed between the foot and far area, and the low and high exposured group. In the foot area, CES-D score was significantly higher in low exposured group than the high exposured group (mean$\pm$SD: 14.3$\pm$10.3 vs. 9.9$\pm$7.7, respectively). There were no significant differences of the summary score of SF-8 and the pulmonary function test between the high and low exposured group. Furthermore, there were no remarkable differences of all parameters between the foot and far area.

Conclusions:

The worsening respiratory symptoms after explosive volcanic eruption were observed in about half of the patients with obstructive lung disease. However, the statistically significant association between the extent of the exposure of volcanic ash and respiratory symptoms, QOL scores and the results of the pulmonary function test was not clear.

Observations by the JMA weather radar network and quantitative predictions of tephra-fall with the JMA RATM for the eruptions at Shinmoe-dake volcano in 2011

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The JMA implemented the Volcanic Ash Fall Forecast in March 2008 and is considering the predictions of lapilli-fall. The Tokyo VAAC has also been provided the Volcanic Ash Dispersion Chart for Sakurajima and Shinmoe-dake volcanoes on trial since July 2010. The technical methods are based on the JMA Regional Atmospheric Transport Model (RATM) driven by the GPVs of operational Mesoscale Model (MSM) or Local Forecast Model (LFM), both of which originated from the JMA Nonhydrostatic Model (NHM).

The RATM for volcanic ash and others has been developed at the MRI (Shimbori et al., 2010; Saito et al., 2013). This is an off-line Lagrangian model which considered the processes of three-dimensional advection, horizontal and vertical diffusion, gravitational settling, dry deposition and wet scavenging. When using the GPVs of LFM (hourly intervals up to 9 hours, 2 km grid spacing, 60 hybrid layers), the number of tracers is 250,000 and the calculation grid spacing of concentration or deposition is 2 km in latitude-longitude coordinate. For the quantitative predictions of tephra-fall, the initial condition of RATM is given by the eruption column model according to Suzuki (1983). Variable input parameters of the model are eruption column height and duration.

In the case of the 2011 eruptions of Shinmoe-dake, one of the active volcanoes in the Kirishima volcano group located in southwestern Japan, many eruption clouds were observed by weather radars. From the radar reflectivity factor observed by JMA's operational C-band weather Doppler radars at Tanegashima, Fukuoka and Kagoshima airport, the time series of the eruption cloud echo heights have been analyzed in detail (Shimbori et al., 2013). Hashimoto et al. (2012) showed that these radar observations yield effective initial data of the eruption column model to well simulate the ash deposition pattern. In the presentation, results of RATM calculations using the radar data will be shown with comparison to the observed ash-fall quantity and lapilli-fall area.

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Numerical Simulation of Transport and Sedimentation of Volcanic Ash for the Eruptions at Mt. Shinmoe-dake during 26-27 January 2011

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The tephra transport and sedimentation associated with the eruptions at Mt. Shinmoe-dake during 26 to 27 January 2011 are investigated with Japan Meteorological Agency Non-Hydrostatic Model (JMA-NHM) in which the mixing ratio and number concentration of tephra particles are prognosed to represent the behavior of tephra in the atmosphere. In the model, one-dimensional eruption column model is applied in order to represent injection of tephra particles into the atmosphere. The release of tephra is expressed by giving the production rates of total mass and number of tephra particles in the grids that compose the column. The production rate is a function of the column height, the level of the release point, and the size of released particle, following Suzuki (1983) and Shimbori et al. (2010). In actual eruption events, the eruption clouds were detected by the Tanegashima and Fukuoka radars of JMA as well as the high-sensitivity camera that is installed about 7.5 km away to the south of Mt. Shinmoe-dake and monitored at Kagoshima Local Meteorological Observatory. Based on the results of radar and camera observations (Shimbori et al., 2013), the temporal change of column height is given during the simulation. Comparison of the model result with ground survey on tephra deposit shows that the model well represents the major axis of tephra deposit and the difference in the grain size on both sides of the axis due to the sheared horizontal wind and a variety of the fall velocity of tephra particles (Hashimoto et al., 2012). On the other hand, the simulated ash cloud goes too far compared with the satellite observation after transported hundreds kilo meters away from the volcano. This means that the long-transported fine particles are released at higher altitude in the model than in the actual atmosphere, since the horizontal wind generally gets stronger in higher altitude. It is indicated that the eruption column model applied in the simulation needs modification with respect to the release rate of tephra particles as a function of the level of the release point and the size of released particle. The current performance and the issues for improvement of the model will be discussed.

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Medical Preparedness for Next Large Eruptions of Sakurajima Volcano

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I will present an estimation of the damage due to next large eruptions of Sakurajima volcano that are as large as Sakurajima Taisho eruption in 1914 and possible emergency medical responses against the disasters caused by that kind of eruptions. While Sakurajima volcano in Kagoshima, Japan is erupting in small-scale Vulcanian style more than a thousand times a year in recent years, it has generated a large-scale eruption including the formation of Plinian plumes with 8000 meters in height and emissions of pyroclastic materials with styles of pyroclastic flows and lava flows in 1914, which is often called "Taisho eruption" in Japan because it has occurred in the era of Taisho emperor. The Taisho eruption resulted in 58 victims and the loss of more than 2,000 buildings partly due to an accompanying earthquake with the magnitude of 6.1 occurred in Kagoshima area on the same day as the beginning of the main phase of the eruption. I assume that the same phenomena as Taisho eruption would occur in the present state, of populations, medical resources and the distributions of medical and evacuation facilities in Kagoshima city and the surrounding area and estimate the possible responses to the volcanic disasters focusing on emergency medical support.

Volcanic Ash Fall Forecasts of Japan Meteorological Agency and its improvement

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The Japan Meteorological Agency (JMA) has issued Volcanic Ash Fall Forecasts (VAFFs) for the nation since March 2008 in Japan. When an eruption which has an effect of ash-fall on wide area occurred, JMA will issue a VAFF which has a graphical format and informs hourly ash fall areas predicted to 6 hours after from the event. JMA issued VAFFs for the 2009 Asamayama eruption, the 2011 Kirishimayama Shinmoe-dake eruptions and recent eruptions of Sakurajima.

It is well known that effects of ash-fall varies with ash-fall quantity and differs among fields such as agriculture, buildings, communication networks, transportation, and so on. Although JMA must inform prediction data of ash-fall quantity on VAFF primarily, we have not been able to do because the JMA's prediction technique of ash-fall quantity, that is the prediction of tephra-fall with the JMA Regional Atmospheric Transport Model, has insufficient prediction accuracy at present.

Meanwhile, the recent development of the JMA's prediction technique with improvement of measurement technique of volcanic plume height using weather radar data by Meteorological Research Institute (MRI) (Shimbori et al., in this session) enabled JMA to inform prediction data of ash-fall quantity on VAFF.

Therefore, JMA plans to improve VAFF on the basis of not only use of the new prediction technique but also user's needs from the research for people living near active volcanoes and opinions from experts of various fields about volcanic ash-fall such as volcanology, disaster prevention, broadcasting, medical service, and so on.

Characteristics of new VAFF are as follows.
- On new VAFF, JMA informs not only prediction data of ash-fall quantity but also that of centimeter-sized lapilli-fall area.
- On new VAFF, JMA also informs effects of ash-fall for people and its preparedness of people to predicted ash-fall quantity.
- New VAFF has 3 types of information: information issued before an eruption, quick and brief information issued just after the eruption and full information issued after the eruption.
- JMA will issue a new VAFF when predicted ash-fall quantity reaches effective level for people or community.
- JMA will make a category table of ash-fall quantity as to effects of ash-fall for people and its preparedness of people, and use this table for new VAFF.

JMA aims to issue new VAFF a few years later.

Environmental impact of acid river neutralization system in the Kusatsu hot spring area, Gunma, Japan

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The Kusatsu hot spring area, located at the eastern foot of the Kusatsu-Shirane volcano, is one of the most famous spa resorts in Japan and originates in hydrothermal activities of the Kusatsu-Shirane volcano. The springs are all strongly acidic, and some of them show relatively high arsenic concentration. Rivers in this area are also all acidic due to acidic hot spring water flows. The Gunma prefectural government started a river water neutralization system to improve water quality downstream in 1964. Today, the system is operated by the Ministry of Land, Infrastructure and Transport. Neutralizer prepared by mixing powdered limestone particle with river water is poured directly into the river. Neutralization results in several thousand tons of neutralization products and other suspended materials being accumulated annually in the Shinaki dam reservoir. Sediment of Shinaki Dam is continuously dredged by water pump to prevent water and sediment from overflowing. After dehydration by a filter press, dredged sediment is dumped at local dedicated disposal sites. Disposal processes are comprehensively monitored due to the arsenic and other heavy metals contained in sediment. In this study, facts about environmental impact of the acid river neutralization system were investigated.

Sediments of Shinaki dam partly contain 1000 to 2000 mg/kg of arsenic in wet basis. The results of the modified BCR sequential extraction procedure on sediment core samples in the dam suggest that arsenic in bottom layer coexist with reduced iron minerals like iron sulfides as As(III) under anoxic conditions while that in surface layer coexist with iron(III) oxyhydroxide minerals, which are probably original forms of neutralization products, as As(V). Dumped sediments in the disposal sites contain around 500 mg/kg of arsenic. The results of leaching experiment with sediment core samples of the disposal sites in pure water reveal that the possibility of dissolution of As(V) from the sediments dumped with cement type solidifier. On the other hand, only trace amounts of As(III) were leached from the sediments dumped without the solidifier. Disposal processes thus strongly affect mobility of arsenic in disposal sites.