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Agenda Item 2: Improving the safety and efficiency of international air navigation through enhanced meteorological service provision
2.1: Enhancement of existing meteorological service provision to support current strategic, pre-tactical and tactical operational decision-making (including ASBU Module B0-AMET)

RADIATION MONITORING AND NUCLEAR ACCIDENT CONSEQUENCE ASSESSMENT IN HONG KONG, CHINA

(Presented by China)

SUMMARY

This paper presents the real-time radiation monitoring and nuclear accident consequence assessment capability in Hong Kong, China. These will be deployed to support the issuance of SIGMET and related advice for the local ATC in case radioactive cloud affects the Hong Kong Flight Information Region (HKFIR).

1. INTRODUCTION

1.1 ICAO Annex 3 requires that Meteorological Watch Office should issue SIGMET for radioactive clouds to its associated ACC/FIC. MET/14-WP/5|CAeM-15/Doc. 5 introduces and MET/14-IP/5|CAeM-15/INF. 5 presents the roadmap concerning future service provision on the release of radioactive material into the atmosphere.

1.2 This paper presents the real-time radiation monitoring and nuclear accident consequence assessment capability in Hong Kong, China. Using the Fukushima accident as an example, the assessment results from a Lagrangian particle dispersion model were compared against the radioactivity measurements that have been put in place for monitoring local radiation level.

2. HISTORY

2.1 The Hong Kong Observatory (HKO) is responsible for environmental radiation monitoring in Hong Kong, China. The work began in 1961 when the Observatory started to measure beta radioactivity of air particulates, total deposition and rain-water at King's Park meteorological station.

2.2 In 1987, in response to the planned establishment of a nuclear power station at Daya Bay in Guangdong, China, about 50 kilometres away from the city centre of Hong Kong, a comprehensive Environmental Radiation Monitoring Programme (ERMP) was implemented.

2.3 In addition to real-time monitoring of the ambient radiation level, an accident consequence assessment system had been put in place since early 1990's to evaluate the potential consequences arising from offsite nuclear emergency. At present, the Realtime Online DecisiOn Support (RODOS) system is adopted for the simulation of atmospheric dispersion and deposition of radionuclides from the release of nearby nuclear power plants, supplemented by the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model for assessment of long distant transportation of radionuclides. Lately, in collaboration with Zentralanstalt für Meteorologie und Geodynamik (ZAMG), Austria, HKO also experimented with the use of the FLEXible PARTicle dispersion model (FLEXPART) in simulating the spread of radioactive release.

3. RADIATION MONITORING

Radiation Monitoring Network

3.1 The ambient gamma dose rates are monitored by a network of 12 fixed stations. The dose rates are measured at each station continuously by a high pressure ionization chamber. Data are transmitted to HKO once every minute. In addition, each of these stations is equipped with a radio-iodine sampler, a high volume air sampler and a total deposition collector. Radioactivity measurements of the collected samples are carried out at the radiation laboratory at King's Park.

Automatic Gamma Spectrometry System

3.2 The system consists of a zinc sulphide coated plastic scintillator, a high purity germanium detector and a sodium iodide detector. It continuously collects airborne particulates on a rotating filter drum and gaseous iodine in a carbon cartridge. Data of alpha and beta activities, iodine-131 activity, as well as results of gamma spectrometry analysis are transmitted to HKO every 5 to 15 minutes.

Mobile Radiation Monitoring Station

3.3 A vehicle is equipped with portable and specially designed instruments for use in routine and emergency radiological surveys. An external gamma probe and an air inlet on the vehicle roof provide the means to measure the ambient gamma radiation levels outside the vehicle and to collect air samples without the survey team members having to leave the vehicle.

Aerial Radiation Monitoring System

3.4 The Aerial Radiation Monitoring System consists of two assemblies of sodium iodide detectors that can be mounted on board a helicopter when in operation. It has two operating mode, viz. the plume tracking mode and ground contamination measurement mode. When in the plume tracking mode, it has the capability to determine the existence and extent of any radioactive plume within the Hong Kong Flight Information Region (HKFIR). Gamma spectra, spectroscopic analysis results and location information are displayed on board the helicopter in real time and archived at regular intervals.

Upper-air Radioactivity Soundings

3.5 Radioactivity in the upper atmosphere is also measured by radioactivity sensors attached to balloon-borne radiosondes. The radioactivity sensor comprises of two Geiger-Muller tubes, one for gamma-only measurement and the other for gamma as well as beta radiation of energies higher than 0.25MeV. Data from the radioactivity sensor is transmitted back to the ground station.

4. TRANSPORT MODELS

RODOS

4.1 RODOS was developed in Europe with the joint effort of almost forty institutes from some twenty countries. One of the key features of RODOS is the ability to assimilate different sources of meteorological data, including real-time actual observations as well as numerical weather prediction (NWP) outputs for the simulation of atmospheric dispersion and deposition over time. RODOS can also assist in providing various decision support information based on the simulation results. The current implementation of RODOS in HKO mainly focuses on short range dispersion and deposition from nearby nuclear power plants.

HYSPLIT

4.2 HYSPLIT was developed by the National Oceanic and Atmospheric Administration (NOAA) to support a wide range of simulations related to the long-range transport, dispersion and deposition of pollutants. It is used at HKO to assess the pathway of radionuclides from distant nuclear power plants and the backward trajectories of pollutants or radionuclides arriving Hong Kong.

FLEXPART

4.3 FLEXPART was originally developed by the Norwegian Institute for Air Research and ZAMG is now the key developer for implementation of nuclear and volcanic ash transport applications. It is a Lagrangian particle dispersion model that can handle multiple particles with diffusion, dry and wet deposition, as well as radioactive decay of the transported materials. Besides experimenting its use in a study of simulation of Fukushima, the potential application of FLEXPART at HKO in nuclear accident consequence assessment is being further explored.

5. SIMULATION OF FUKUSHIMA EVENT

5.1 Minute amounts of ^{131}I and ^{137}Cs were detected from some of the daily air samples collected through high volume air samplers in late March and early April 2011. The measurement results from the daily airborne samples are summarized in Table 1 and Figure 1.

5.2 A joint study with ZAMG was conducted to assess the pathway of the first arrival of ^{131}I in Hong Kong. FLEXPART was employed to simulate the transportation of radioactive release from the Fukushima accident. The results presented below are based on the simulation with source term from Chino *et al.* (2011) and modified by Terada *et al.* (2012), together with global meteorological data, based on actual analysis by the National Centers for Environmental Prediction (NCEP) at 0.5° horizontal resolution and 3-hour temporal resolution. The model run initialized at 00 UTC on 11 March 2011, covers the period from 11 to 31 March 2011. Outputs include near-surface activity concentration and deposition.

5.3 Figure 2 shows the simulated activity concentration of ^{131}I over eastern Asia and western North Pacific from 13 to 29 March 2011. It is noted that initially, the radioactive materials followed the westerlies and spread eastwards. Some of them were influenced by the cyclonic circulation over Bering Sea and turned in an anti-clockwise direction towards the China-Russia border near Heilongjiang. The radioactive materials then travelled southwards along the eastern coast of China and reached Hong Kong on 27 March.

5.4 From the simulation results, some radioactive materials over the western north Pacific were transported quickly towards the southwest and reached the Philippines on 23 March. This was consistent with the detection of artificial radionuclide by the CTBTO station at the Philippines on 23 March as shown in Figure 3.

5.5 Time series of the simulated ^{131}I activity in Hong Kong at 12 UTC from 26 to 31 March is shown in Figure 4. The model result could rightly depict the rise in ^{131}I activity after 26 March, although it under-estimated the values by about one order of magnitude.

6. CONCLUSION

6.1 The dispersion of radioactive substances from Fukushima was closely related to changes in the atmospheric conditions and synoptic patterns. Numerical tools, such as FLEXPART, proved very useful for assessing the spread of the plume arising from a point source and explaining the likely movement scenarios followed by the released radioactive substances.

6.2 However, the case of Fukushima fully showed reliable source terms for assessing accident severity and consequences in real-time were not readily available in the early phase given the rather challenging circumstances. In fact, even in the post-analyses of source terms for the accident, results can still vary significantly due to different simulation techniques and weather prediction scenarios. The inherent uncertainty involved poses questions in the accuracy of the modelled results which could differ from the observation by orders of magnitude. This highlights the importance of local radioactivity measurements in nuclear emergency response, in the preparation of SIGMET and in advising the local ATC on the safety of flights in the affected airspace.

6.3 The adoption of some kind of ensemble approach by taking various potential release situations into consideration for scenario assessment may be helpful, especially when an imminent off-site release is expected and yet the plant conditions remain unclear. For better support of international aviation, it is considered worthwhile to explore the possibility of having a suite of numerical models, deploying a multi-scale and multi-model system, including numerical weather prediction in the regional scale; and trajectory forecast for a fast and quick assessment, as well as more accurate atmospheric transport modelling for flexible deployment and integrated implementation.

6.4 The availability of timely radiation monitoring data is of utmost importance to the assessment of the severity and impacts of a nuclear accident. It is also considered worthwhile to explore the feasibility of integration of various radiation monitoring networks, at a global or a regional level, for better support of international aviation as well as enhancing future national and regional capacities in nuclear emergency preparedness and response.

7. ACTION BY THE MEETING

7.1 The meeting is invited to note the information contained in this paper.

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APPENDIX

Table 1. Activity of ^{131}I and ^{137}Cs in King's Park Daily Airborne Particulate Samples

Sampling Date[2]	**Activity of ^{131}I**[1] **[MDA: 0.1-0.2] (mBq/m^3)**	**Activity of ^{137}Cs**[3] **[MDA: 0.1-0.2] (mBq/m^3)**
16 March to 26 March 2011	Below MDA	Below MDA
27 March 2011	0.06 ± 0.06	Below MDA
28 March 2011	0.19 ± 0.07	Below MDA
29 March 2011	0.30 ± 0.07	Below MDA
30 March 2011	0.83 ± 0.12	Below MDA
31 March 2011	0.65 ± 0.10	Below MDA
1 April 2011	0.36 ± 0.09	Below MDA
2 April to 5 April 2011	Below MDA	Below MDA
6 April 2011	0.26 ± 0.06	Below MDA
7 April 2011	0.32 ± 0.07	Below MDA
8 April 2011	0.06 ± 0.07	Below MDA
9 April 2011	0.17 ± 0.08	0.07 ± 0.02
10 April 2011	0.14 ± 0.06	Below MDA
11 April 2011	0.17 ± 0.08	Below MDA
12 April 2011	Below MDA	Below MDA
13 April 2011	0.15 ± 0.05	0.03 ± 0.03
14 April 2011	0.07 ± 0.05	Below MDA
15 April to 25 May 2011	Below MDA	Below MDA

[1] Results of radionuclide analyses are reported as "xx ± yy", where xx is the activity level and yy is the counting uncertainty at the 95% confidence level.

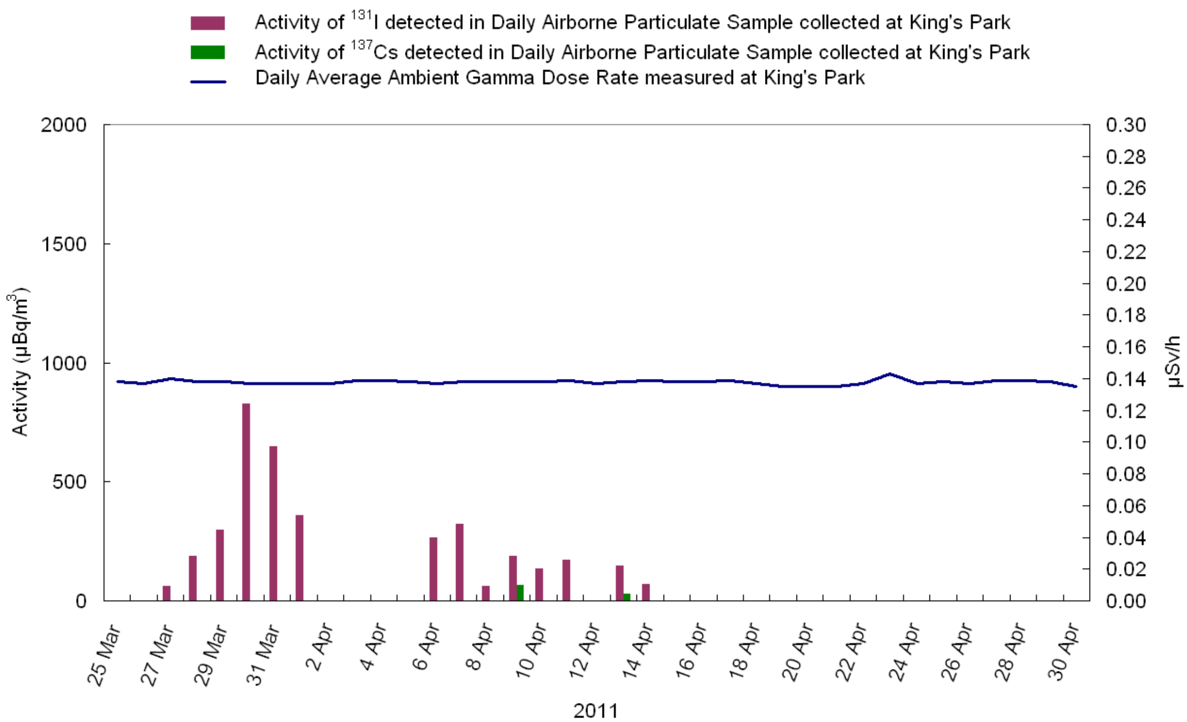

Figure 1. Daily average ambient gamma dose rates measured and activity of ^{131}I and ^{137}Cs in daily airborne particulate samples collected at King's Park from 25 March to 30 April 2011

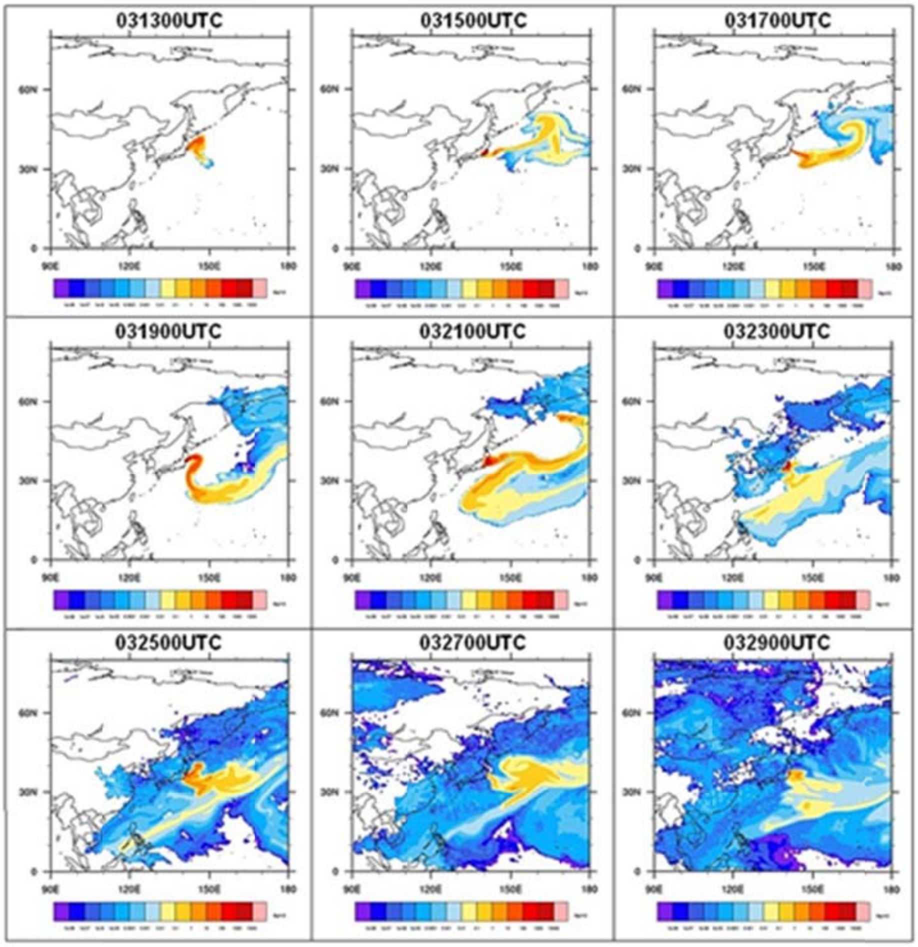

Figure 2. Distribution of activity concentration of ^{131}I over the western north Pacific and eastern Asia from 13 to 29 March 2011

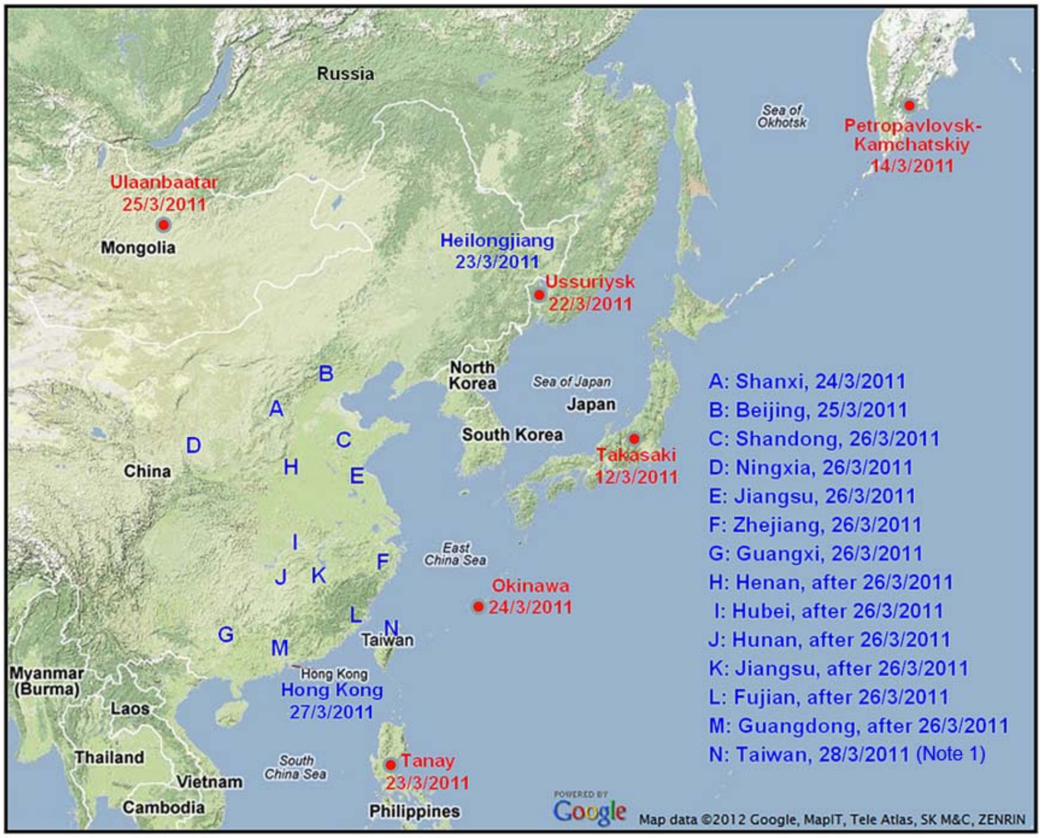

Figure 3. Dates of first detection of ^{131}I from airborne particulates originating from the Fukushima nuclear accident as detected in various places over Asia

CTBTO monitoring stations are marked with red dots, while those operated by local authorities are marked in blue.

Note 1.— The sampling period for monitoring stations in mainland China and Hong Kong was 24 hours, while that in Taiwan was a 7-day period from 22 to 28 March.

Note 2.— Data sources: CTBTO; Radiation Monitoring Technical Centre, Hangzhou; and Taiwan Atomic Energy Council).

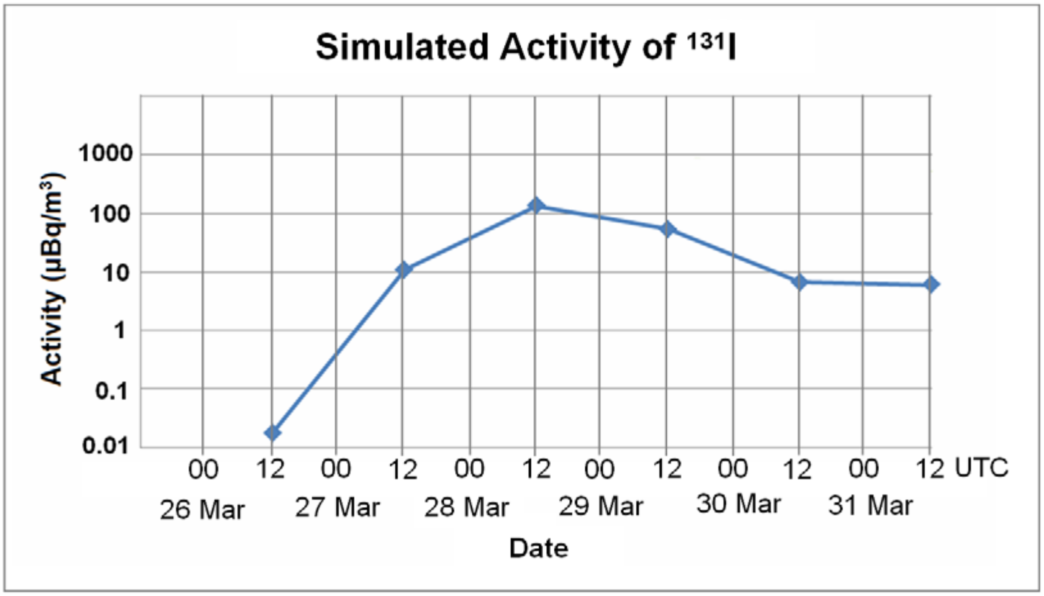

Figure 4. Simulated activity of 131I in Hong Kong at 12 UTC from 26 to 31 March 2011

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