United Nations Scientific Committee on the Effects of Atomic Radiation

ATTACHMENT

COMPARISON OF MEASUREMENTS OF IODINE-131 CONCENTRATIONS IN AIR WITH ESTIMATES USING ATDM

Developments since the 2013 UNSCEAR report on the levels and effects of radiation exposure due to the nuclear accident following the great east-Japan earthquake and tsunami

A 2016 white paper to guide the Scientific Committee's future programme of work

Notes

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Contents

I. AIM

1.   The aim of this paper is to compare measurements of ^{131}I concentrations in air as reported by Hirayama et al. [H1] with ^{131}I concentrations in air as estimated using atmospheric transport, dispersion and deposition models (ATDM) alone (and in combination with measurements of iodine-131 deposited on the ground) for the 2013 UNSCEAR report on the levels and effects of radiation exposure due to the nuclear accident following the great east-Japan earthquake and tsunami [U1].

II. BACKGROUND

2.   Hirayama et al. [H1] assessed the distribution of ^{131}I concentration in air with time from measurements made in March 2011 at several monitoring posts in Fukushima Prefecture using peak count rates and the calculated response of NaI(Tl) detectors. The locations of the monitoring posts are indicated by red squares in figure I. Hirayama et al. [H1] estimated ^{131}I concentrations in air from the measurements as hourly values. The data provide a new and valuable source of information on ^{131}I concentrations in air during the first days of the accident for which very few direct measurements have previously been published.

3.   For the 2013 report two different approaches had been used by the Committee to estimate ^{131}I concentrations in air (and resulting inhalation doses):

–   For settlements within the evacuated areas, ^{131}I concentrations in air had been evaluated using an estimate of the source term (including the temporal and spatial patterns of release) [T1] together with appropriate ATDM;

–   For all other locations, the Committee had relied on measurements of the deposition densities of radionuclides as the basis for its estimates of ^{131}I concentrations in air. ATDM results were used to evaluate the concentrations of radionuclides in air from measured deposition densities on the ground by scaling the measured deposition densities using the ratio of the concentration in air and deposition density estimated by ATDM.

The ATDM calculations had been carried out by a task team of the World Meteorological Organization (WMO). The ATDM calculations had used a regular grid with a grid spacing of

0.05° and the results were in the form of time-integrated concentrations in air over three-hour intervals. The grid cells located close to the monitoring posts considered by Hirayama et al. [H1] are shown in figure I as green circles.

III. APPROACH

4.   For all monitoring posts, a comparison has been made of measurements and estimates of ^{131}I concentrations in air using the following approach:

- For each monitoring post (considered by Hirayama et al. [H1]), the closest ATDM grid cell or cells was/were identified, see red lines in figure I;

- For each monitoring post, the hourly estimates made by Hirayama et al. [H1] of ^{131}I concentration in air were integrated over the same three-hour intervals used in the ATDM calculations and also over the whole monitoring period;

- For each ATDM grid cell, the ATDM results were also integrated over the whole time period covered by the ATDM calculations (i.e. from 00:00 on 12 March 2011 until 03:00 on 4 April 2011);

- The time integrals (over relevant periods) of ^{131}I concentrations in air were then compared, see figures II–IV and table 1.

5.   For monitoring posts located beyond the evacuation area, an additional comparison has been made between the time-integrated concentrations derived from hourly estimates made by Hirayama et al. [H1] and those estimated in the 2013 report using ATDM in combination with measured levels of ^{131}I deposition densities.

6.   The former comparisons are, in general, relevant to the estimation of doses to those evacuated, which were based on ATDM calculations alone. The latter are relevant to the estimation of doses in non-evacuated areas that were based on ATDM combined with measured deposition densities.

Figure I. Location of monitoring posts considered in Hirayama et al. [H1] (red squares) and closest UNSCEAR ATDM grid cells (green circles). The red lines indicate the closest ATDM grid cell for each monitoring post
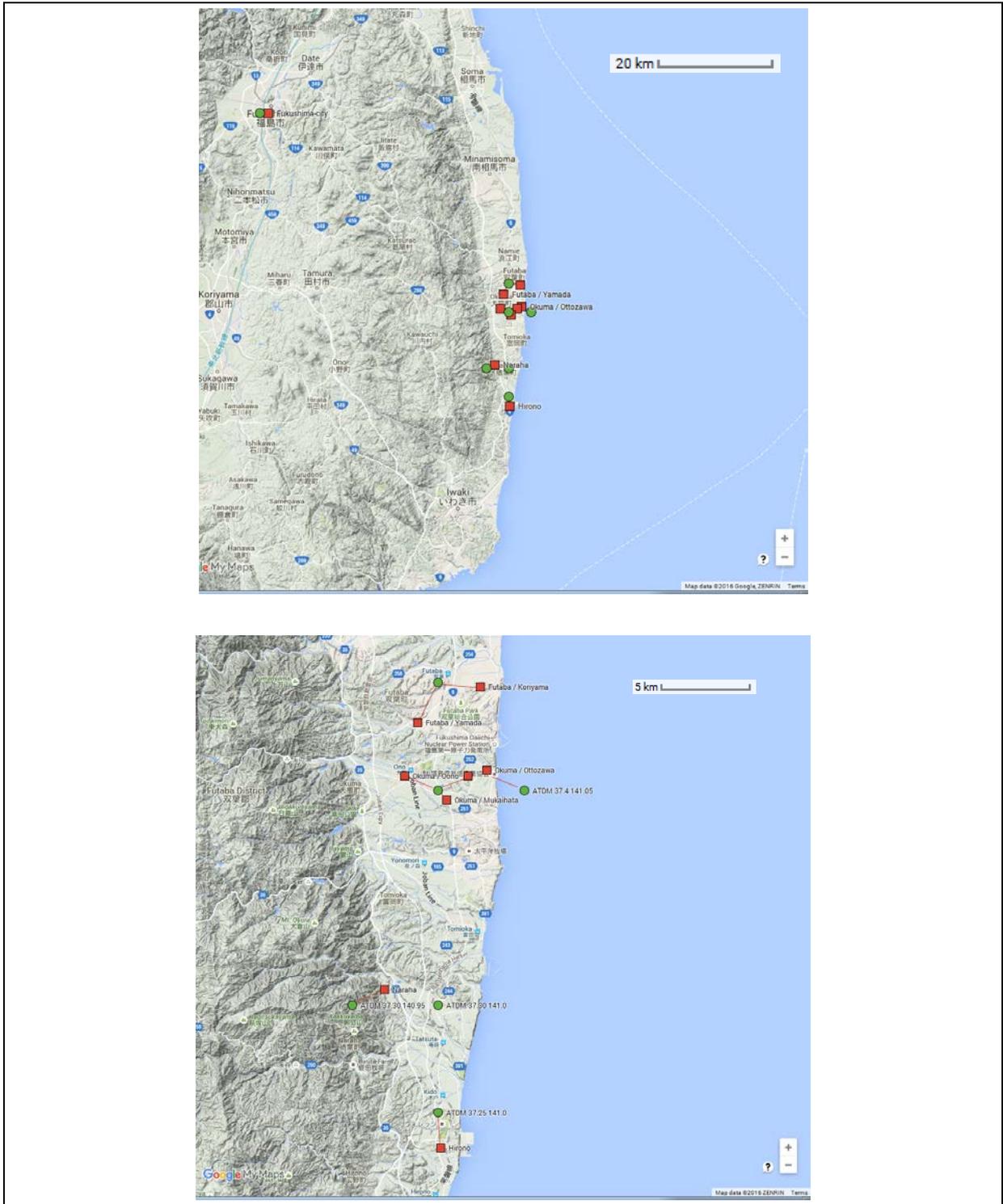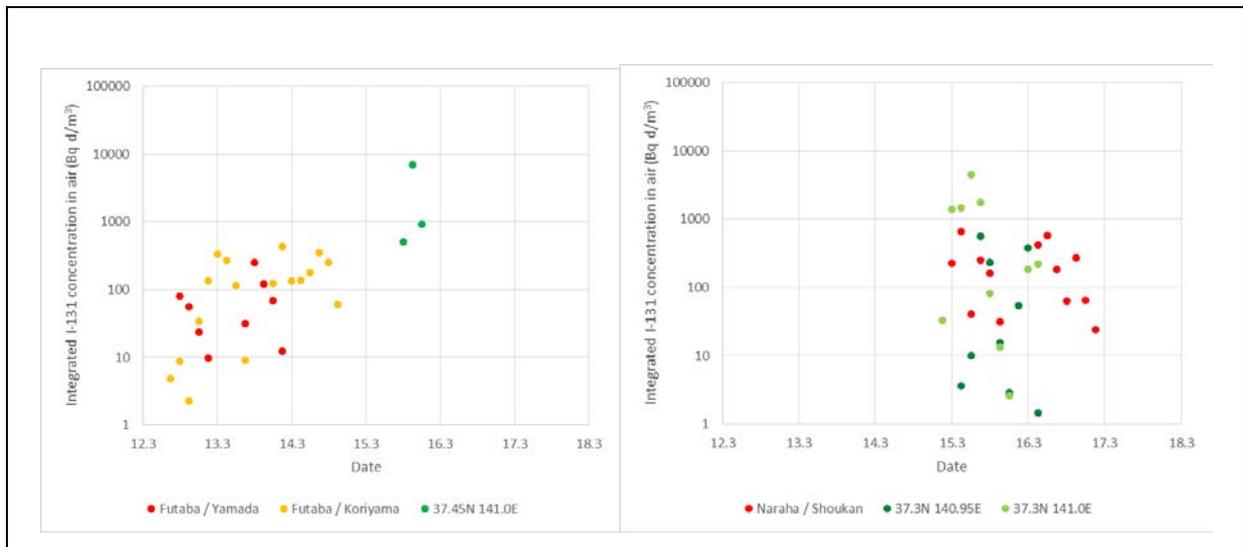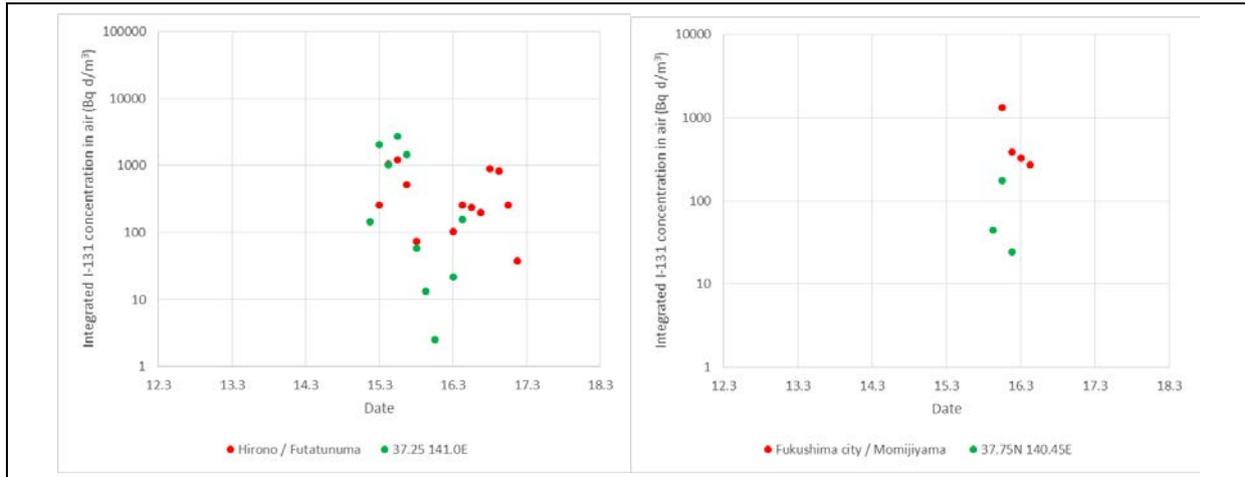
IV. RESULTS

Figure IIa/b. Comparison of ^{131}I concentrations in air integrated over three-hour intervals for Okuma (green points are ATDM results)
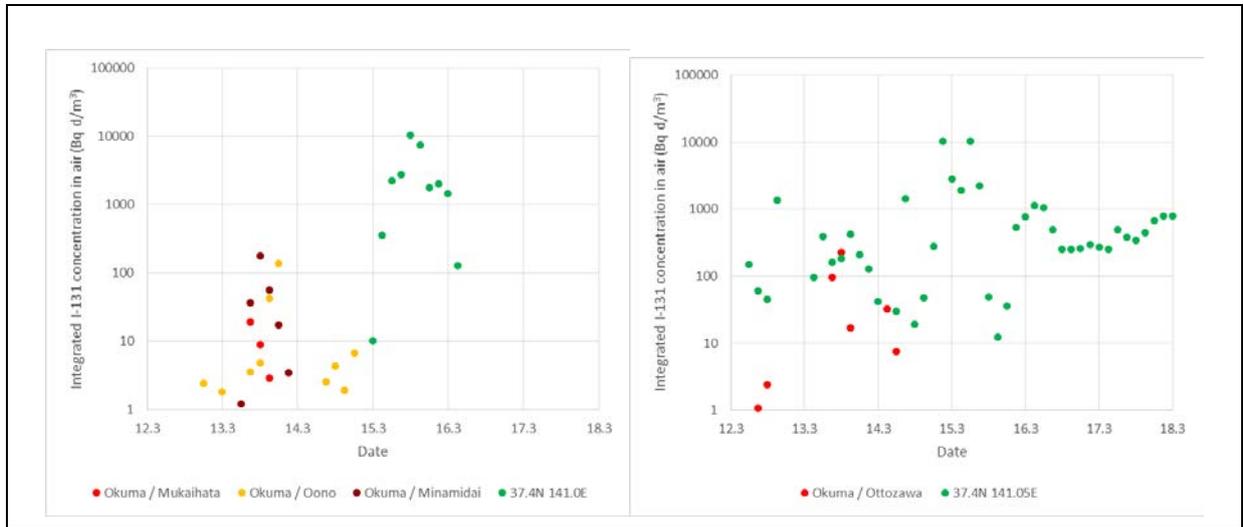
Figure IIIa/b. Comparison of ^{131}I concentrations in air integrated over three-hour intervals for Futaba and Naraha (green points are ATDM results)

Figure IVa/b. Comparison of ^{131}I concentrations in air integrated over three-hour intervals for Hirono and Fukushima City (green points are ATDM results)

7.   Figures II to IV show a comparison of ^{131}I concentrations in air integrated over three-hour intervals for Okuma, Futaba, Naraha, Hirono and Fukushima City. From the figures, it is apparent that, in some of the comparisons, there are significant differences. Specifically, the measurements indicate an earlier arrival time of a smaller radioactive plume for three of the monitoring posts in Okuma and the two in Futaba (see figures IIa and IIIa), and a lack of measurements for the monitoring posts in Okuma and Futaba for the period when the ATDM calculations predict the passage of a larger radioactive plume (see figures IIa, IIb, IIIa). In these cases, Hirayama et al. [H1] have stated, in an additional publication [H2], that data for these monitoring posts after 20:00 on 14 March "could not be analysed because of a drastic increase or a lack of data". Given the very large increases in airborne radionuclide concentrations predicted by ATDM after the 14 March, a reasonable inference would be that the absence of monitoring data after this time was due to saturation or other common-mode failure of these monitors. Meaningful comparisons with ATDM predictions cannot, therefore, be made for these monitoring posts after 14 March. The comparison of ^{131}I concentrations in air for Okuma and Futaba is also limited by the grid resolution of the ATDM calculations, as well as that of the underlying meteorological data, being of the same order of magnitude as the distance between the closest monitoring points and the release point.

8.   The remaining comparisons (see figure IIIb for Naraha/Shoukan, figure IVa for Hirono/Futatunuma, and figure IVb for Fukushima City/Momijiyama) show better agreement, consistent with *(a)* the uncertainties inherent in ATDM predictions, *(b)* the differences between the locations of the monitoring posts and those for which ATDM predictions were made, and *(c)* the uncertainties associated with the method used (and acknowledged) by Hirayama et al. [H1] to estimate radionuclide concentrations in air from measured count rates.

9.   Table 1 presents a comparison of the ^{131}I concentration in air integrated over the whole time period covered by the ATDM calculations (i.e. from 00:00 on 12 March 2011 until 03:00 on 4 April 2011) with time-integrated concentrations measured at these three monitoring posts. This comparison indicates agreement within a factor of about two for the monitoring posts at Shoukan (Naraha) and Futatunuma (Hirono) and within a factor of about eight for the monitoring post at Momijiyama (Fukushima City). This level of agreement is again in line with the uncertainties underlying the comparison.

Table 1. Comparison of time-integrated ^{131}I concentrations in air from Hirayama et al. [H1] with estimates based on ATDM carried out for the 2013 report^a

Data from [H1]		2013 report ATDM predictions [U1]		
Monitoring post	Time-integrated ^{131}I concentration in air (Bq d/m^3)	Town/city	ATDM grid cell	Time-integrated ^{131}I concentration in air (Bq d/m^3)
Shoukan	6 000	Naraha	37.3N 140.95E	4 100
	6 000	Naraha	37.3N 141.0E	15 000
Futatunuma	6 000	Hirono	37.25N 141.0E	12 000
Momijiyama	2 700	Fukushima City	37.75N 140.45E	340

^{a} All values quoted to two significant figures.

10.   For Hirono and Fukushima City, ^{131}I concentrations in air (and resulting inhalation doses) were estimated in the Committee's 2013 report, not from ATDM estimates alone, but in combination with measured deposition densities (i.e. using ATDM to scale measurements of deposition density). Table 2 shows a comparison of the results from Hirayama et al. [H1] for the monitoring posts closest to these two locations with the time-integrated ^{131}I concentration in air estimated in this way. For both locations, the agreement is good given the inherent uncertainties in the measured and estimated values: the estimated concentrations in air are a few tens of per cent lower than those measured. The agreement is better than that between measured levels and estimates based on ATDM alone (see table 1). This supports the approach adopted in the 2013 report to assess radionuclide concentrations in air (and subsequently inhalation doses) primarily based on the measured deposition densities, with ATDM (together with an assumed source term) used to derive scaling ratios.

Table 2. Comparison of time-integrated ^{131}I concentrations in air from Hirayama et al. [H1] with estimates carried out for the 2013 report based on ATDM scaling of deposition measurements^a

Data from [H1]		Estimates based on method used in 2013 report [U1] (using ATDM to scale measured deposition densities)		
Monitoring post	Time-integrated ^{131}I concentration in air (Bq d/m^3)	Town/city	ATDM grid cell	Time-integrated ^{131}I concentration in air (Bq d/m^3)
Futatunuma	6 000	Hirono	37.25N 141.0E	4 100
Momijiyama	2 700	Fukushima City	37.75N 140.45E	2 200

^{a} All values quoted to two significant figures.

11.   The measurements also provide support for the estimates made in the 2013 report of radionuclide concentrations in air (and subsequently doses) to which evacuees were exposed prior to their evacuation from Futaba and Okuma. These evacuations were completed before 12 March, and the ATDM estimates indicated that there were no exposures prior to this time. The measurements at Futaba and Okuma show the arrival of air masses with elevated concentrations of ^{131}I at varying times during the day of 12 March (i.e. after the evacuation had been completed) and, as such, confirm the estimates in the 2013 report.

References

H1   Hirayama, H., H. Matsumura, Y. Namito et al. Estimation of time history of I-131 concentration in air using NaI(Tl) detector pulse height distribution at monitoring posts in Fukushima prefecture. Trans At Energy Soc Japan 14(1): 1-11 (2015). (Japanese).

H2   Hirayama, H., H. Matsumura, Y. Namito et al. Method to separate plume- and accumurated surrounding-contributions to peak count rate using pulse height distribution time histories at monitoring post. KEK Internal 2014-7. High Energy Accelerator Research Organization (KEK), Japan, 2015.

T1   Terada, H., G. Katata, M. Chino et al. Atmospheric discharge and dispersion of radionuclides during the Fukushima Dai-ichi Nuclear Power Plant accident. Part II: verification of the source term and analysis of regional-scale atmospheric dispersion. J Environ Radioact 112: 141-154 (2012).

U1   UNSCEAR. Sources, Effects and Risks of Ionizing Radiation. Volume I: Report to the Genera Assembly and Scientific Annex A. UNSCEAR 2013 Report. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations sales publication E.14.IX.1. United Nations, New York, 2014.