Dear Prof. Dagmar Hainbucher

Thank you very much for your comment and your decision.

I modified the chapter 2.7 and chapter 4.4.

In this mass balance equation, I was estimated the net in/outflowed ^{137}Cs in each box. In the surface sea water, ^{137}Cs activity concentrations (or inventory) are controlled by radioactive decay, inflow from the upstream box, outflow to the downstream box, and downward transport below the surface mixed layer.

[^{137}Cs inventory]box,ti+5 = [^{137}Cs inventory]box,ti-[radioactive decayed ^{137}Cs]box,Δt-[net in/outflowed ^{137}Cs]box,Δt   (8)

Because estimates of ^{137}Cs transport amount in these processes were very difficult in this study, outflowed ^{137}Cs by these processes were represented as "net in/outflowed ^{137}Cs" in each box. In this study, I showed the estimation in every 5 years after 1975 by using the previous 5years inventory value. In the case of 1970, ^{137}Cs deposition amount until 1970 was used as an initial value.

I modified these chapters as follows.

The modified parts were described by green (for ver 5) and purple (for ver 6) colors text.

2.7. Mass balance; net in/outflow of ^{137}Cs in each box

In the marine environment, ^{137}Cs activity concentrations after 1970 were dominantly controlled by radioactive decay and physical ocean processes, except for the release by accident and reprocessing plants. As the physical oceanographic processes, ^{137}Cs in the surface seawater in each box receive inflow from the upstream box, outflow to the downstream box, and downward transport below the surface mixed layer. In fact, estimates of ^{137}Cs transport amount in these processes were very difficult in this study. Therefore, outflowed ^{137}Cs by these

processes were represented as net in/outflowed ^{137}Cs in each box. Mass balance of ^{137}Cs in the surface mixed layer was considered as following equations.

$[^{137}$Cs inventory$]_{box, \ ti+5}$ = $[^{137}$Cs inventory$]_{box,ti}$-[radioactive decayed ^{137}Cs$]_{box, \ \Delta t}$ -[net in/outflowed ^{137}Cs$]_{box, \Delta t}$ (8)

[radioactive decay$]_{box, \Delta t}$ = $[^{137}$Cs inventory$\times$exp(-0.693/T$_{1/2}\times\Delta t)]_{box}$ (9)

[net in/outflowed ^{137}Cs] $_{box, \ ti+5}$= [inflowed ^{137}Cs$]_{box, \ ti}$ + [outflowed ^{137}Cs$]_{box, \ ti}$ 10)

+ [downwards transport of ^{137}Cs below the surface mixed layer] $_{box,ti}$

      where,

      Δt : 5 years

      ti : 1970+i$\times$5 (i=0,1,···, 9).

  $[^{137}$Cs inventory$]_{box, \ ti}$ is the value at initial year and $[^{137}$Cs inventory$]_{box, \ ti+5}$ is the ^{137}Cs inventory after the Δt year in each box. In this study, this mass balance was estimated to be every 5 years from 1970 to 2015. In the case of 1970, ^{137}Cs deposition amount until 1970 was used as the value of the initial year in each box. In the northern North Atlantic Ocean and Arctic Ocean, an extremely large inflow was estimated in 2000 due to the extremely large values included in the dataset. These data in 2000 and 2005 were removed from the figures.

●   Line 1339-1401

Estimation of the net in/outflow amount of ^{137}Cs

The ^{137}Cs deposited into the ocean surface is transported via advection and diffusion in the surface seawater as well as transported to deep water below the surface mixed layer depth, where it undergoes radioactive decay (T$_{1/2}$ = 30.17 yr).

●   Line 1408-1410

By using the mass balance equations described in chapter 2.7, net in/outflowed ^{137}Cs amount in each box are shown in Fig. 18-21. Fig. 18 shows the horizontal distributions of the net in/outflowed ^{137}Cs amount in the surface mixed layer in 1970 against the ^{137}Cs deposition amount until the 1st of January 1970 (Fig. 5). Positive values (red) indicate that net inflowed ^{137}Cs amount is larger, whereas negative values (blue) indicate that net outflowed ^{137}Cs amount is larger in each Box.

●   Line 1420-1428

The temporal variation in the net in/outflowed pattern of the ^{137}Cs amount is shown in Figs. 19-21. Fig. 19 shows the net in/outflowed ^{137}Cs amount in each area in the global ocean from 1975 to 2015 at 5-year intervals. The net in/outflowed ^{137}Cs amount corresponds to the sum of the ^{137}Cs amount for the previous five years. In 1975, 1980 and 1985, the values in the subarctic, western, and eastern North Pacific Ocean were negative (-0.5--2.7 PBq; -0.4--1.8 PBq; and -0.03--1.2 PBq, respectively), suggesting that the net outflowed ^{137}Cs amount is larger than those in the net inflowed ^{137}Cs amount. On the other hand, the net in/outflowed ^{137}Cs in the subtropical North Pacific Ocean and equatorial Pacific Ocean showed positive values (0.1-1.3 PBq; 0.08-1.3 PBq; and 0.07-1.3 PBq, respectively). The net inflowed ^{137}Cs also occurred in the subtropical eastern South Pacific Ocean (5.2 and 1.1 PBq) and Southern Ocean (1.7 and 1.7 PBq) in 1975 and 1980 and the eastern South Pacific Ocean (0.8 PBq) in 1980. Distribution of negative and positive values reflect the ^{137}Cs transport pattern:

- Line 1464-1479

Figure 18: Horizontal distribution of the ^{137}Cs net in/outflow amount in each box against the deposition amount in 1970 based on the 0.5-year ^{137}Cs activity concentration data. The amount of ^{137}Cs net outflow includes the downwards transport portion below the surface mixed layer and horizontal transport in the surface mixed layer to the downstream boxes. A positive value (red) indicates the net inflowed ^{137}Cs amount, and negative values (blue) indicate the net outflowed ^{137}Cs amount. (a) Global ocean, (b) northern North Pacific Ocean and its marginal seas, (c) Irish Sea and English Chanel. The unit is PBq.

- Line 1436-1439

Figure 19: Mass balance of ^{137}Cs in the surface seawater in each box in the global ocean. A positive value (red) indicates net inflowed ^{137}Cs amount from the upstream boxes, and negative value (blue) indicates net outflowed ^{137}Cs amount to the downstream boxes or below the surface mixed layer compared to the previous 5 years. The unit is PBq. (a) 1975, (b) 1980, (c) 1985, (d) 1990, (e) 1995, (f) 2000, (g) 2005, (h) 2010, and (i) 2015.

- Line 1613-1615-

Figure 20: Mass balance of ^{137}Cs in the surface seawater in each box in the northern North Atlantic Ocean and its marginal seas. A positive value (red) means the net inflowed ^{137}Cs amount from the upstream boxes, and a negative value (blue) indicates net outflowed ^{137}Cs amount to the downstream boxes or below the surface mixed layer compared to the previous 5years. The unit is PBq. (a) 1975, (b) 1980, (c) 1985, (d) 1990, (e) 1995, (f) 2000, (g) 2005, (h) 2010, and (i) 2015.

- Line 1678-1681

Figure 21: Mass balance of ^{137}Cs in the surface seawater in each box in the Irish Sea and English Chanel. A positive value (red) indicates net inflowed ^{137}Cs amount from the upstream boxes, and a negative value (blue) indicates net outflowed ^{137}Cs amount to the downstream boxes or below the surface mixed layer compared to the previous 5years. The unit is PBq. (a) 1975, (b) 1980, (c) 1985, (d) 1990, (e) 1995, (f) 2000, (g) 2005, (h) 2010, and (i) 2015.

Thank you very much again.   Yayoi Inomata