The author's respond to the Reviewer #1

We are very grateful to the Reviewer for a very careful reading of the manuscript and a number of useful comments and critics we tried to take into account in the revised version. Our point-to-point responses can be found below.

The main changes made

We have modified our simulation code and recalculated all the results with this new code. The code, used in the previous version of our manuscript (ms) for plotting figures, underestimated the amount of yellow tracers from the area around the Fukushima Nuclear Power Plant (FNPP) advected outside that area and had a high risk to be contaminated. As before, we distribute a large number of particles in a large area in the northwestern Pacific on a fixed date and advected them backward in time. In the previous code, the particles, which crossed the yellow rectangular around the FNPP (Fig.1a) in the past for the period from the day of accident, March 11, 2011 to May 18, 2011, have been marked by the yellow color on the corresponding Lagrangian map. The particles, which were present in that area and leaved it after May 18, have not been colored in yellow. However, those particles also have a risk to be highly contaminated and should be specified as yellow ones. The present code specifies all those particles as yellow ones. As the result, some "white" waters, which have not been specified previously, now have been specified to came from the yellow area around the FNPP with a high risk to be contaminated.

We've cardinally rewritten Secs. 3.1, 3.2 and 3.3 to compare more clearly our simulation results with the measurements by Buesseler2012, Kaeriyama2013, Kuramoto2014 and Budyansky2015. With this aim we imposed on Figs.2c, 2d, 4a and 4d locations of stations with measured values of the cesium concentration levels in collected surface seawater samples in 2011 and 2012. For convenience, we place an updated version of the main Sec.3 'Results' to the end of the respond along with figures being changed.

When working on a revised version of our ms, we have found the paper by Kumamoto, Y. et al. Southward spreading of the Fukushima-derived radiocesium across the Kuroshio Extension in the North Pacific. Sci. Rep. 4, 4276; DOI:10.1038/srep04276 (2014). Seawater samples for radiocesium measurements in the frontal area have been collected during the R/V 'Mirai' cruise in the very beginning of February 2012. We used this new possibility to compare our simulations with this new data. We imposed on the simulated Lagrangian map in Fig.4a locations of stations to the north of the Kuroshio Extention (>36N) with measured levels of the cesium concentrations and found a good qualitative correspondence of those measurements with our simulation results 10 months after the accident in the sense that stations with measured background level are in the area of Oyashio ``blue'' waters with low risk to be contaminated, whereas stations with comparatively high level of radiocesium concentrations are in the area of Fukushima-derived ``yellow'' waters with increased risk of contamination.

I. Reviewer #1: Recommendation -

This paper presents Lagrangian maps that visualize the origin, history and fate of the water masses in the mesoscale eddies off the coast of Japan. From the results, the authors argued: 1) the potential risk of contaminated water derived from the Fukushima nuclear power plant, 2) transition of water properties included in the mesoscale eddies and 3) qualitative correspondence between the Lagrangian maps with the observed Cs-137 data (Buesseler et al., 2012, Kaeriyama et al., 2013).

The methodology is very interesting and the authors arguments 1) and 2) are understandable. However, the argument 3) is not supported by the results presented by this work. Consequently, I recommend to reinforce the argument 3) with their results presented in this work. The concrete problems regarding the argument 3) are described below.

Responses to the First Reviewer's report (Problems regarding the argument 3)

1. Cited from the referee's report

p. 9 L. 32-p. 10 L. 7: This paragraph is totally describing results by Prants et al. (2014) and not by this paper. The observed data by Kaeriyama et al. (2013) showed especially high Cs-137 concentrations in the green segment of Fig. 2d. The result of this study showed that the green segment is corresponding to the blue color water mass (Fig.2d), which means Cs-137 concentrations are low. The authors need to address this inconsistence and discuss possible reasons explaining it.

Our response

We removed that paragraph from the revised test. We recalculated all the results and imposed on the updated version of Fig. 2d locations of stations in the end of July 2011 with measured values of the cesium concentration levels in collected surface seawater samples by Kaeriyama et al. (2013). We removed colored segments in updated version of Fig.2. The green segment in former Fig. 2d corresponds to stations 43 (41N), 44 (40.5N), 45 (40N) and 46 (39.5N) marked by the magenta diamonds in the updated version of Fig. 2d.

'Station 43 was located inside the anticyclone HE filled mainly by ``yellow'' waters, and we estimate the risk to found Fukushima-derived radionuclides there to be large. Station 44 was located at the southern periphery of the anticyclone HE at the boundary between ``white'' and ``blue'' waters but in close proximity to a ``yellow'' streamer.'
(cited from the updated version of Sec.3.2).

As to stations 45 and 46, the following text has been added to the updated version of Sec.3.1:
'However, there is an inconsistence of simulation with samplings at stations 45 and 46 where there are practically now yellow tracers but only blue and white ones. The reasons of this inconsistence might be different. In this paper we track only those tracers which were originated from the blue, red and black segments and the yellow rectangular around the FNPP shown in Fig.1a. So we did not specify the origin of white waters. They could reach their places on the maps from anywhere besides those segments and the area around the FNPP. They could in principle contain Fukushima-derived radionuclides deposited at the sea surface from the atmosphere after the accident and then being advected by eddies and currents in the area. Moreover, they could be those tracers which have been located inside AVISO grid cells near the coast around the FNPP just after the accident and then have been advected outside. We removed from consideration all the tracers entered into any AVISO grid cell with two or more corners touching the land because of inaccuracy of the altimetry-based velocity field there and in order to avoid artifacts. Thus, the white streamers inside the core and at the periphery of the blue cyclone with the center at \N{39.7}, \E{144.2} at the places or nearby stations 45 and 46 with high measured concentrations of cesium by \citep{Kaeriyama13}, could, in principle, contain contaminated water. However, it has not been proved in our simulation by the mentioned reasons' (cited from the updated version of Sec.3.1).

2. Cited from the referee's report

p. 10 L. 26-29: Kaeriyama's transect is not reaching to "yellow water"; I do not agree with the authors conclusion is supported by the observation by Kaeriyama et al. (2013).

Our response

As it is clearly seen in the updated version of Fig. 2d, the Kaeriyama's transect reaches to 'yellow' water. Its northern station 43 was located inside the anticyclone HE filled mainly by ``yellow'' waters, and we estimate the risk to found Fukushima-derived radionuclides there to be large. It is supported by the measurements of concentration of Cs 137 by Kaeriyama et al. (2013) to be around 71 mBq/kg at that station.

3. Cited from the referee's report

p. 11 L. 4-13: This paragraph is describing results by Budyansky et al. (2015). There are no discussion for correspondence between the Lagrangian map with the observed data.

Our response

Our ms is intended for a wide audience, not only to specialists in radioactivity measurements. The corresponding paragraph really describes mainly some results by Budyansky et al. (2015). We put it to the context because the measurements by Budyansky et al. (2015) and some simulation results in that paper support our conclusions about the role of the Tsugaru eddy (TsE) in transport and mixing of Fukushima-derived radionuclides. Moreover, we imposed on updated version of Fig. 4d location of station 84 with measured increased values of the cesium concentration levels in July2012, 15 months after the accident.

Other isuues

4. Cited from the referee's report

p. 9 L. 11: The meridional transect by Buesseler et al. (2012) is 144E, not 145E.

Our response

Thank you, it's our mistake. The meridional transect by Buesseler et al. (2012) is shown in Fig.2c and in its caption to be along 144E, not 145E. We corrected this mistake in the main text.

5. Cited from the referee's report

It is strongly recommended to add figures comparing the Lagrangian maps with the observed data. The comparisons are described in text, but they are hard to understand as readers need to look around the papers Buesseler et al. (2012) and Kaeriyama et al. (2013). Their data are publicly available and number of the data are not so many, it is easy to make figures to compare the Laglangian maps with the observed data.

Our response

We have done that and imposed on Figs.2c, 2d and 4d locations of stations with measured values of the cesium concentration levels in collected surface seawater samples in 2011 and 2012. We thank again the Reviewer for advising that. It helped us not only to improve the ms but forced us to recalculate all the results.

The updated version of the main Sec.3 'Results' along with figures being changed

above. They could reach their places on the maps from anywhere besides those segments.

We are interested in advective transport for a comparatively long period of time, up to two years. It is hardly possible to simulate adequately motion of a specified passive particle in a chaotic flow, but it is possible to reproduce transport of statistically significant number of particles. Our results are based not on simulation of individual trajectories but on statistics for 490,000 Lagrangian particles. We cannot, of course, guarantee that we compute "true" trajectories for individual particles. The description of general pattern of transport for half a million particles is much more robust. However, we do not try to simulate quantitatively concentration of radionuclides or estimate the content of water masses of different origin inside the studied eddies.

3 Results

A few mesoscale eddies were present in the studied area to the day of the accident. The cyclonic eddies with the centers at downward-oriented triangles on the Lagrangian maps prevailed in the area to the north of the Subarctic Front, the boundary between the subarctic ("blue") and subtropical ("red") waters in Fig. 2. The anticyclonic eddies with the centers at upward-oriented triangles prevailed to the south of the front.

The large anticyclonic Tohoku eddy (TE) with the center at around 39° N, 144° E in March 2011 has been sampled after the accident in the two R/V cruises in June (Buesseler et al., 2012) and July 2011 (Kaeriyama et al., 2013) to have large concentrations of ^{137}Cs and ^{134}Cs. The anticyclonic Hokkaido eddy (HE), genetically connected with the TE, was born in the middle of May 2011 with the center at around 40° N, 145° E. After that it captured some contaminated water from the TE. It has been sampled in the end of July 2011 (Kaeriyama et al., 2013).

The anticyclonic Tsugaru eddy (TsE) was genetically connected with the HE. It was born in the beginning of February 2012 with the center at around 41.9° N, 148° E and captured some contaminated water from the HE. The TsE has been sampled in the R/V "*Professor Gagarinskiy*" cruise on July 5, 2012 to have concentrations of ^{137}Cs and ^{134}Cs over the background level at the surface and in intermediate depths (Budyansky et al., 2015). All these eddies will be studied in this section from the Lagrangian point of view in order to simulate and track by which transport pathways they could gain water masses from the Fukushima area and water masses of other origin and to compare qualitatively the simulation results with *in situ* measurements.

3.1 The Tohoku eddy

We tracked with daily-computed Lagrangian maps the birth, metamorphoses and decay of the mesoscale anticyclonic TE. It was born in the middle of May 2010 with the elliptic point at around 38° N, 144° E at that time as the result of interaction of a warm anticyclonic Kuroshio ring with a cyclone with mixed Kuroshio and Oyashio core waters. It has interacted with another eddies almost for a year with multiple splitting and merging in the area to the east off the Honshu Island. Just after the accident, it begun to gain "yellow" water from the area around the FNPP with a high risk of contamination. That eddy is clearly seen in earlier simulation just after the accident in Fig. 3b by Prants et al. (2011b) and on the Lagrangian map in Fig. 2a as a red patch labeled as TE with the center at 39° N, 144° E on March 26, 2011.

The maps in Fig. 2 and in the subsequent figures have been computed as it was explained in Sec. 2. The red color in the core of the TE means that its core water was of subtropical origin. More exactly, the red tracers came for two years in the past to their places on the map from the red line segment in Fig. 1a crossing the Kuroshio jet. In March 2011 "yellow" water, coming from the area around the FNPP with a comparatively high risk to be contaminated, wrapped round the TE. A thin streamer of Tsugaru "black" water, coming from the black line segment in Fig. 1a, wrapped a periphery of the TE to the end of March. "Yellow" waters propagated gradually to the east and south due to a system of currents sometimes wrapping round the eddies to be present in the area. The straight zonal boundary along 36.5° N and meridional boundary along 144° E, separating water masses of different origin in Fig. 1a on March 26, 2011, are just fragments of the yellow straight lines in Fig. 2a restricting the area around the FNPP. These boundaries separate the "yellow" tracers which were present within the area from those ones which have not yet managed to penetrate inside the area for 15 days after the accident.

In April and May 2011 the TE had a sandwich-like structure with the red subtropical core belted with a narrow streamer of Fukushima "yellow" waters which, in turn, was encircled by a red streamer of Kuroshio subtropical water (Fig. 2b). A new eddy configuration appeared to the end of May in Fig. 2b with the TE interacting with a "blue" cyclone with the center at 39.9° N, 144.7° E and a newborn "yellow" anticyclone which we call the Hokkaido eddy (HE) with the center at 40.4° N, 145.5° E. The core of that cyclone consisted of a "blue" subarctic Oyashio water with low risk to be contaminated, but the HE core water came from the area around the FNPP with a high risk to be contaminated.

In the course of time the TE moved gradually to the south. Its periphery has been sampled in the beginning of June by Buesseler et al. (2012), and the whole eddy has been crossed in the end of July 2011 by Kaeriyama et al. (2013). Fukushima-derived cesium isotopes have been measured on June 10 and 11 during the R/V "*Ka'imikai-o-Kanaloa*" cruise (Buesseler et al., 2012) along the 144° E meridional transect where the cesium concentrations have been found to be in the range from the background level, $C_{137} = 1.4 - 3.6$ mBq/kg

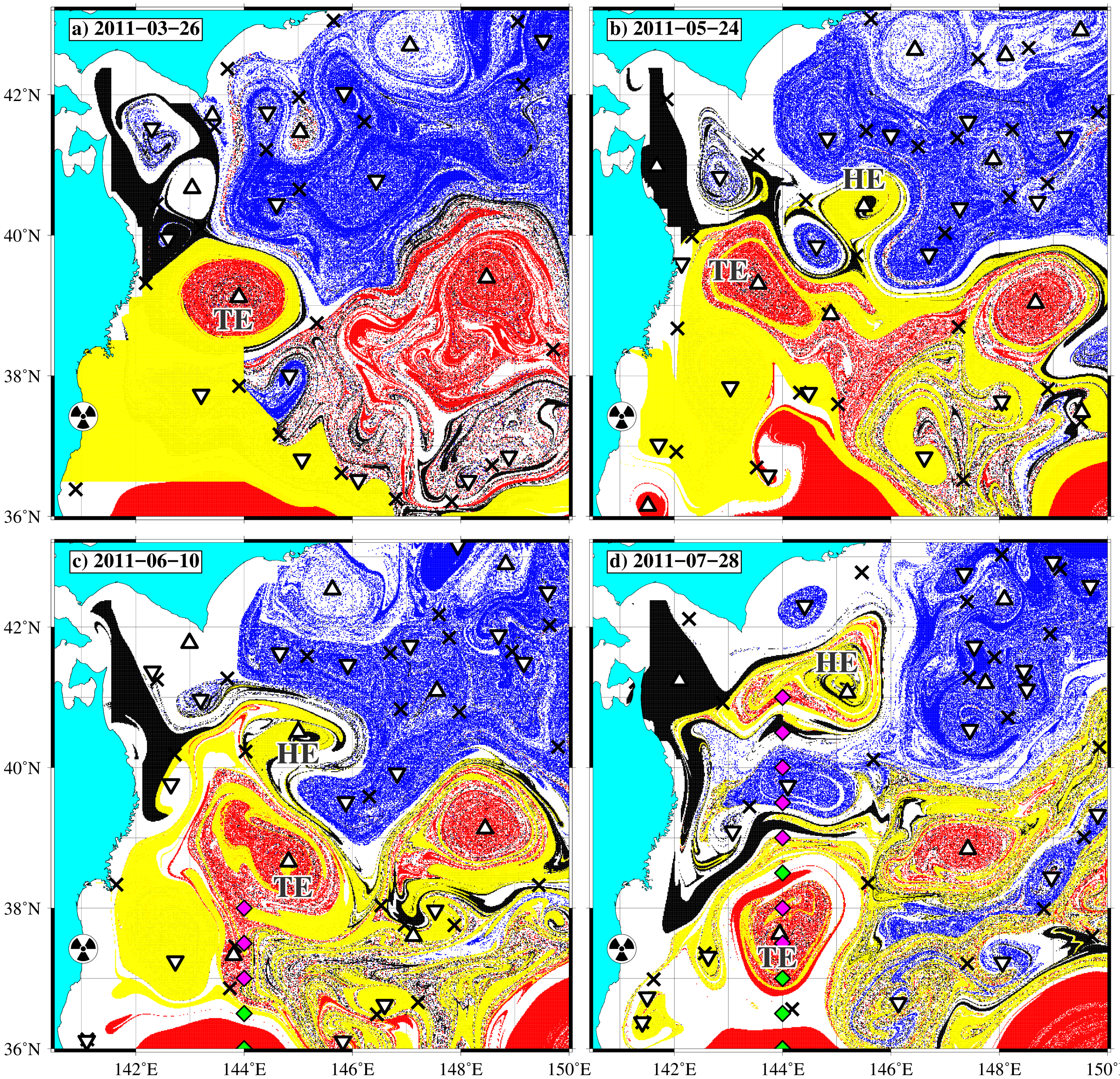

Figure 2. The Lagrangian maps show evolution of the Tohoku eddy (TE) after the accident to the days of its sampling and the origin of waters in its core and at the periphery. The red, black and blue colors specify the tracers which came for two years in the past to their places on the maps from the Kuroshio, Oyashio and Tsushima currents, respectively, more exactly, from the corresponding line segments shown in Fig. 1a. The yellow color marks the Lagrangian particles coming from the area around the FNPP in Fig. 1a after the day of the accident on March 11, 2011. The TE has been sampled on June 10 and 11, 2011 by Buesseler et al. (2012) along the transect 35.5° N – 38° N, 144° E shown in panel c) and in the end of July 2011 by Kaeriyama et al. (2013) along the transect 35° N – 41° N, 144° E shown in panel d). The locations of stations with collected by Buesseler et al. (2012) and (Kaeriyama et al., 2013) surface seawater samples with measured radiocesium concentrations at the background level are indicated by the green diamonds. Stations, where the concentrations have been measured to be much higher, are marked by the magenta diamonds.

(stations 13 and 14), to a high level up to $C_{137} = 173.6 \pm 9.9$ mBq/kg (station 10). The ratio ^{134}Cs/^{137}Cs was close to 1.

For ease of comparison, we mark in Fig. 2c by the green diamonds the locations of stations 13 and 14 with collected surface seawater samples by Buesseler et al. (2012) in which

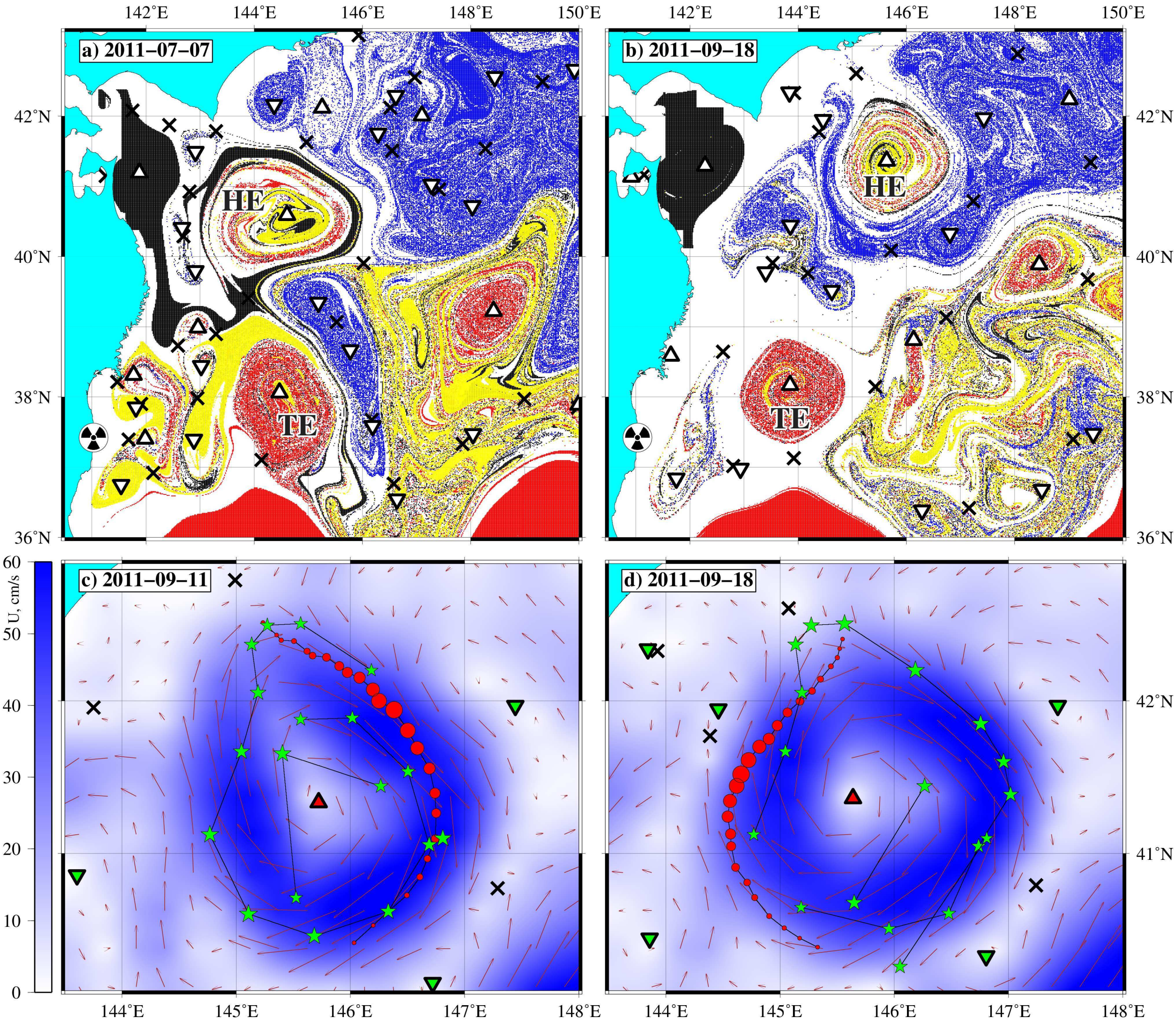

Figure 3. a) and b) The Lagrangian maps show evolution of the Hokkaido eddy (HE) after the FNPP accident to the days of its sampling and the origin of waters in its core and at the periphery. c) and d) A fragment of the track of the drifter no. 39123 is indicated by the full circles for two days before the day indicated with the size of circles increasing in time. Tracks of three ARGO floats are shown by the stars. The largest star corresponds to the day indicated and the other ones show float positions each 5 days before and after that date.

the cesium concentrations have been measured to be at the background level. The stations 10, 11 and 12, where the concentrations have been found to be much larger, are indicated by the magenta diamonds. Our simulation in Fig. 2c shows that stations 13 and 14 on the days of sampling have been located in "red" and "white" waters with a low risk to contain Fukushima-derived radionuclides.

Transport and mixing at and around stations 10, 11 and 12 with high measured values of the cesium concentrations by Buesseler et al. (2012) have been governed mainly by the interaction of the TE with the "yellow" mesoscale cyclone with the center at 37.2° N, 142.8° E. This cyclone formed in the area in April and captured "yellow" waters with a high risk of contamination. Unfortunately, it has not been sampled in the R/V "*Ka'imikai-o-Kanaloa*" cruise. The surface seawater samples at stations 10, 11 and 12, have been collected on the days of sampling at the eastern periphery of that cyclone and at the southern periphery of the TE with the "yellow" streamer there. Station 10 with the highest measured level of the ^{137}Cs concentration, $C_{137} = 173.6 \pm 9.9$ mBq/kg, was located at 38° N, 144° E inside the wide streamer of "yellow" water around the TE. Stations 11 and 12 with $C_{137} = 103.7 \pm 5.9$ mBq/kg and $C_{137} = 93.6 \pm 4.9$ mBq/kg, respectively, have been located within the narrow streamers with

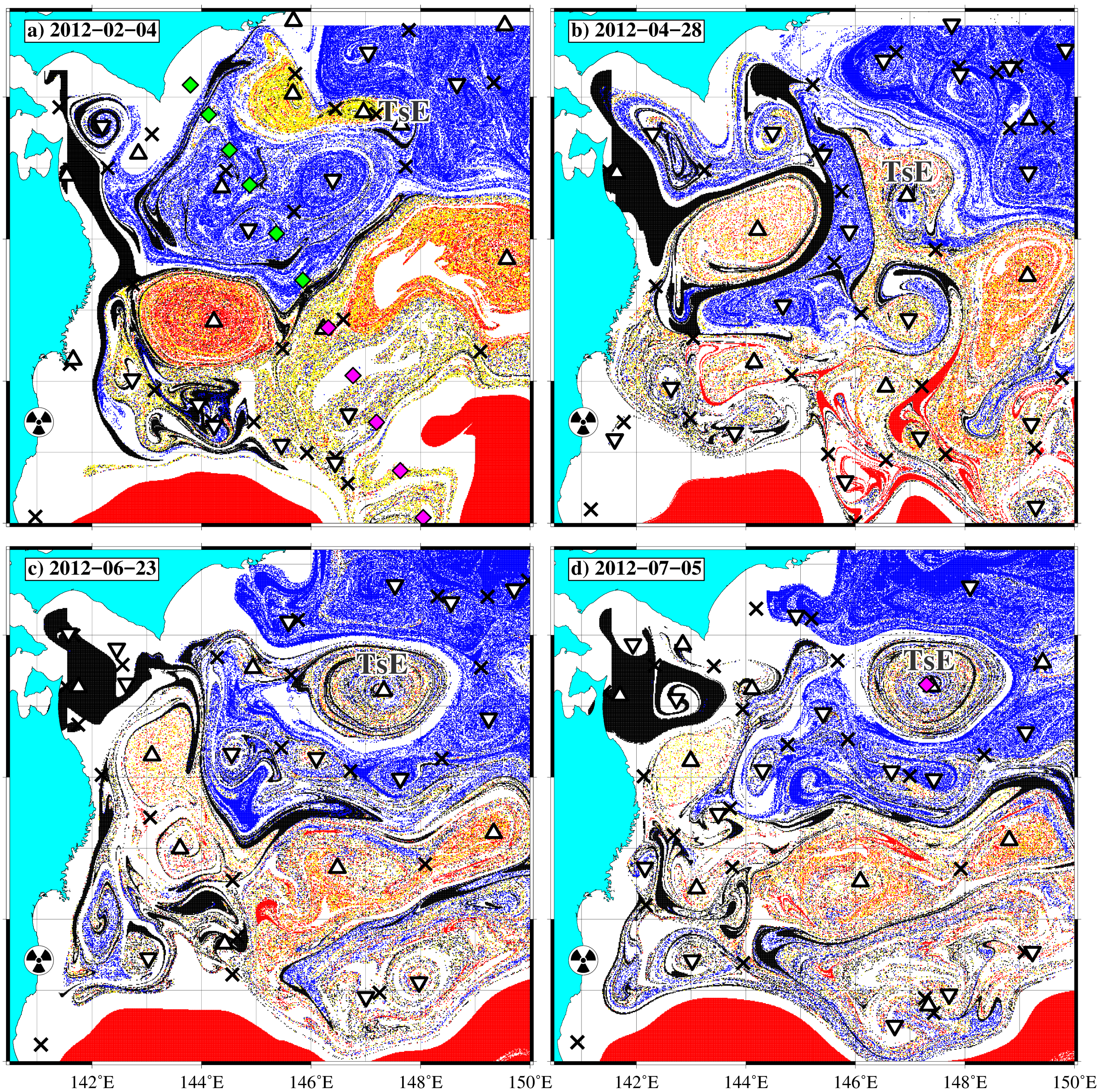

Figure 4. The Lagrangian maps in the study area in the first half of 2012. a) The locations of stations in the beginning of February with collected by Kumamoto et al. (2014) surface seawater samples with measured radiocesium concentrations at the background level (the green diamonds) and with higher concentration levels (the magenta diamonds). b) – d) The Lagrangian maps show evolution of the Tsugaru eddy (TsE) which was born on February 4, 2012 (panel a) after splitting of the HE and sampled by Budyansky et al. (2015) at station 84 on July 5, 2012 to have increased radiocesium concentrations (the magenta diamond in panel d).

"yellow" simulated water in Fig. 2c intermitted with narrow streamers of "red" water. So, we estimate the risk to find Fukushima-derived radionuclides there (the magenta diamonds) to be much higher than at stations 13 and 14 (the green diamonds) and it is confirmed by a qualitative comparison with measured data.

A specific configuration of mesoscale eddies occurred in the area to the northeast of the FNPP to the end of July 2011, the days of sampling by Kaeriyama et al. (2013) along the 144° E meridian from 35° N to 41° N in the R/V "*Kaiun maru*" cruise. That transect is shown in Fig. 2d. It crosses the TE and the cyclone with "blue" Oyashio water, which is genetically linked to the "blue" cyclone at 39.9° N, 144.7° E in Fig. 2b. The transect also crosses partly the periphery of the anticyclonic HE. The measured ^{137}Cs concentrations in surface seawater samples at the stations C43–C55 have been found to be in the range from the background level, 1.9 ± 0.4 mBq/kg, (station C52) to a much higher level of 153 ± 6.8 mBq/kg (station C47). The colored tracking maps in Fig. 5 by Prants et al. (2014) show where the simulated tracers of that transect were walking from March 11 to April 10, 2011 being advected by the AVISO velocity field.

The risk of radioactive contamination of the markers placed at 36° N – 36.5° N was estimated by Prants et al. (2014) to be small, because they have been advected mainly by the Kuroshio Current from the southwest to the east (the corresponding concentrations have been measured by Kaeriyama et al. (2013) to be 2–5 mBq/kg). The present simulation in Fig. 2d also shows that stations C51, 52 and 53 (the green diamonds) with the measured cesium concentrations at the background level on the days of sampling by Kaeriyama et al. (2013) have been located in the "red" waters (stations C51 and C53) advected by the main Kuroshio jet from the southwest and in the "white" waters (station C52) between the TE and the jet. Therefore, we estimate a risk to find Fukushima-derived radionuclides there to be comparatively low.

The transect 36.5° N – 38° N in Fig. 2d (the red one in Fig. 5 by Prants et al. (2014)) crossed the TE. The ^{137}Cs concentrations at the stations C49 and C50 of that transect have been measured to be 36 ± 3.3 and 50 ± 3.6 mBq/kg (Kaeriyama et al., 2013). Comparing those results with simulated ones, we note the presence of "yellow" water in the TE core at the locations of those stations. Surface samples at station C48 (38.5° N) have been measured to contain the ^{137}Cs concentration to be at the background level 2.7 ± 0.6 mBq/kg (Kaeriyama et al., 2013). The corresponding green diamond is located in our simulation in the area with "red" and "white" waters.

Inspecting the Lagrangian maps on the days between June 6 and July 28 (not shown), we have found that the "yellow" cyclone with the center at 37.2° N, 142.8° E in Fig. 2c collapsed in the end of June. Its "yellow" core water with a high risk to be contaminated has been wrapped around the neighbor anticyclone TE in the form of a wide yellow streamer visible in Fig. 2d. The highest concentration $C_{137} = 153 \pm 6.8$ mBq/kg has been measured by Kaeriyama et al. (2013) at station C47 (39° N) situated in the area of that streamer. Stations C46 (39.5° N) with $C_{137} = 83 \pm 5.0$ mBq/kg is situated in the close proximity to a yellow streamer sandwiched between "white" and "black" waters.

Comparatively high concentration $C_{137} = 65 \pm 4.3$ mBq/kg has been measured by Kaeriyama et al. (2013) at station C45 (40° N) that was on the days of sampling in the core of the "blue" cyclone with the center at 39.7° N, 144.2° E (Fig. 2d). Our simulation shows that it has been formed mainly by Oyashio "blue" waters (with a low risk to be contaminated by Fukushima-derived radionuclides) and partly by "white" waters.

When comparing simulation results in Fig. 2d with the measurements by Kaeriyama et al. (2013), we have found that the simulation consists with samplings at stations C48, 51, 52 and 53 in the sense that the cesium concentrations have been measured to be at the background level in those places on the maps where there is no signs of "yellow" water with a high risk to contain Fukushima-derived radionuclides. Our simulation consists at least quantitatively also with samplings at stations C47, 49 and 50 with high measured levels of the cesium concentrations because the "yellow" water presents there in our simulation.

However, there is an inconsistency of simulation with samplings at stations C45 and C46 where there are practically now yellow tracers but only blue and white ones. The reasons of this inconsistency might be different. In this paper we track only those tracers which were originated from the blue, red and black segments and the yellow rectangular around the FNPP shown in Fig. 1a. So we did not specify the origin of white waters. They could reach their places on the maps from anywhere besides those segments and the area around the FNPP. They could in principle contain Fukushima-derived radionuclides deposited at the sea surface from the atmosphere after the accident and then being advected by eddies and currents in the area. Moreover, they could be those tracers which have been located inside AVISO grid cells near the coast around the FNPP just after the accident and then have been advected outside. We removed from consideration all the tracers entered into any AVISO grid cell with two or more corners touching the land because of inaccuracy of the altimetry-based velocity field there and in order to avoid artifacts.

Thus, the white streamers inside the core and at the periphery of the blue cyclone with the center at 39.7° N, 144.2° E nearby stations C45 and C46 with high measured concentrations of cesium by Kaeriyama et al. (2013), could, in principle, contain contaminated water. However, it has not been proved in our simulation by the mentioned reasons.

3.2 The Hokkaido eddy

Now we consider the anticyclonic HE. It was born in the middle of May (see the yellow patch in Fig. 2b with the center at 40.3° N, 145.5° E) being genetically linked to the TE. During May, the TE gradually lost a Fukushima "yellow" water from its periphery to form the core of the HE. Fig. 3a shows the HE with a yellow core surrounded by modified subtropical "red" water which, in turn, is surrounded by Tsugaru "black" water.

The sampling of that eddy and its periphery by Kaeriyama et al. (2013) along the 144° E meridian in the end of July showed comparatively high concentrations, $C_{137} = 60 \pm 4.0$ and 71 ± 4.6 mBq/kg at stations C44 (40.5° N) and C43 (41° N), respectively. Station C43 was located inside the anticyclone HE filled mainly by “yellow” waters, and we estimate the risk to found Fukushima-derived radionuclides there to be large. Station C44 was located at the southern periphery of the anticyclone HE at the boundary between “white” and “blue” waters but in close proximity to a “yellow” streamer.

The location of the HE on August 24, 2011 is shown in the AVISO velocity field in Fig. 1b. To verify the simulated locations of the HE and its form, we plot in Figs. 3c and d fragments of the tracks of a drifter and three ARGO floats captured by that eddy in September 2011. A fragment of the track of the drifter no. 39123 is shown by the red circles with the size increasing in time for two days before the dates indicated in Figs. 3c and d and decreasing for two days after those dates, i.e. the largest circle corresponds to the drifter position at the indicated date. It was launched after the accident on July 18, 2011 at the point 45.588° N, 151.583° E in the Oyashio Current, advected by the current to the south and eventually captured by the HE moving around clockwise. Fragments of the clockwise tracks of the three ARGO floats are shown in Figs. 3c and d by stars for seven days before and seven days after the indicated dates. The float no. 5902092 was released long before the accident on September 9, 2008 at the point 32.699° N, 145.668° E to the south off the Kuroshio Extension jet and was able to cross the jet and to get far north. The float no. 2901019 was released before the accident on April 19, 2010 at the point 41.723° N, 146.606° E. The float no. 2901048 was released just after the accident on April 10, 2011 at the point 37.469° N, 141.403° E nearby the FNPP.

Our simulation shows that the HE contained after its formation in the middle of May 2011 a large amount of a “yellow” water probably contaminated by the Fukushima-derived radionuclides. This conclusion is supported by an increased concentration of radiocesium measured in its core at station C43 by Kaeriyama et al. (2013) in the end of July 2011. The HE persisted in the area around 42° N, 148° E up to the end of January of the next year. It splitted eventually on January 31, 2012 into two anticyclones.

3.3 The Tsugaru eddy

The anticyclonic TsE was born on February 4, 2012 after decay of the HE (the yellow patch with the elliptic point at 42° N, 145.6° E in Fig. 4a). The elliptic point at the center of the TsE appeared at 41.8° N, 146.9° E. Just after its birth, the HE begun to transport its “yellow” water around the TsE with the core consisted of an Oyashio “blue” water (Fig. 4b). The strong Subarctic Front is visible in Fig. 4 as a contrast boundary between Oyashio “blue” water and Fukushima-derived “yellow” water with the Tsugaru “black” water in between.

Seawater samples for radiocesium measurements in the frontal area have been collected during the R/V “*Mirai*” cruise from January 31 to February 5, 2012 along one of observation lines of the World Ocean Circulation Experiment (WOCE) in the western Pacific, specifically the WOCE-P10/P10N line (Kumamoto et al., 2014). We impose on the simulated Lagrangian map in Fig. 4a locations of stations to the north of the Kuroshio Extension (>36° N) with measured levels of the cesium concentrations. As before, the green diamonds mark locations of those stations, P10-114 (42.17° N, 143.8° E), P10-112 (41.75° N, 144.13° E), P10-110 (41.25° N, 144.51° E), P10-108 (40.76° N, 144.88° E), P10-106 (40.08° N, 145.37° E) and P10-104 (39.42° N, 145.85° E), where the cesium concentrations in surface seawater samples have been measured by Kumamoto et al. (2014) to be at the background level.

The stations, P10-102 (38.75° N, 146.32° E), P10-100 (38.08° N, 146.77° E), P10-98 (37.42° N, 147.2° E), P10-96 (36.74° N, 147.63° E) and P10-94 (36.08° N, 148.05° E), where the concentrations have been found to be larger (but not exceeding 25.19 ± 1.24 mBq/kg for ^{137}Cs), are indicated by the magenta diamonds. It’s worth to stress a good qualitative correspondence with our simulation results 10 months after the accident in the sense that stations with measured background level are in the area of Oyashio “blue” waters with low risk to be contaminated, whereas stations with comparatively high levels of radiocesium concentrations are in the area of the Fukushima-derived “yellow” waters with increased risk of contamination.

As to the TsE, it was sampled later, in July 5, 2012, in the cruise of the R/V “*Professor Gagarinskiy*” (Budyansky et al., 2015) when it was a comparatively large mesoscale eddy around 150 km in diameter with the elliptic point at 41.3° N, 147.3° E consisting of intermittent strips of “blue” and “yellow” waters (Fig. 4d) which have been wrapped around during its growth from February to July 2012. Station 84 in that cruise was located near the elliptic point of that eddy (called as G by Budyansky et al. (2015)). The concentrations of ^{137}Cs at the surface and at 100 m depth have been measured to be 11 ± 0.6 mBq/kg and 18 ± 1.3 mBq/kg, respectively, an order of magnitude larger than the background level. As to the ^{134}Cs concentration, it was measured to be smaller, 6.1 ± 0.4 mBq/kg and 10.4 ± 0.7 mBq/kg due to a shorter half-lifetime of that isotope. In fact, it was one of the highest cesium concentrations measured inside all the eddy features sampled in the cruise 15 months after the accident.

The maximal concentration of radionuclides was observed, as expected, not at the surface but within subsurface and intermediate water layers (100–500 m) in the potential density range of 26.5–26.7 due to a convergence and subduction of surface water inside anticyclonic eddies. The corresponding tracking map in Fig. 10c by Budyansky et al. (2015) confirms its genetic link with the TE, and, therefore, a probability to detect increased cesium concentrations was expected to be comparatively large. We were able to track all the modification of the TsE up and its death on April 16, 2013 in the area around 40° N, 147.5° E.