



EGU2020 Live chat

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Comparison of ^{137}Cs activity between an ocean general circulation model and the global database

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Introduction

- ◆ We investigate the oceanic dispersion of ^{137}Cs (half-life of 30.1 years) and its impact on the environment.
- ◆ ^{137}Cs activities measured for scientific purposes as well as environmental health and safety monitoring have been summarized in a historical database by IAEA.
- ◆ The spatio-temporal density of the observations varies widely, therefore simulation by an ocean general circulation model (OGCM) can be helpful in the interpretation of these observations.

Input process of ^{137}Cs

	Term	Domain
Global Fallout	1945-	Global Ocean
Reprocessing Plant	1950-1985	Atlantic Ocean
Bikini close-in fallout	1946-1958	Pacific Ocean
Chernobyl input	1986	Atlantic Ocean
Fukushima input	2011-	Pacific Ocean

In this study, we focused on the supply of ^{137}Cs to the Pacific Ocean before the Fukushima Daiichi Nuclear Power Plant accident.

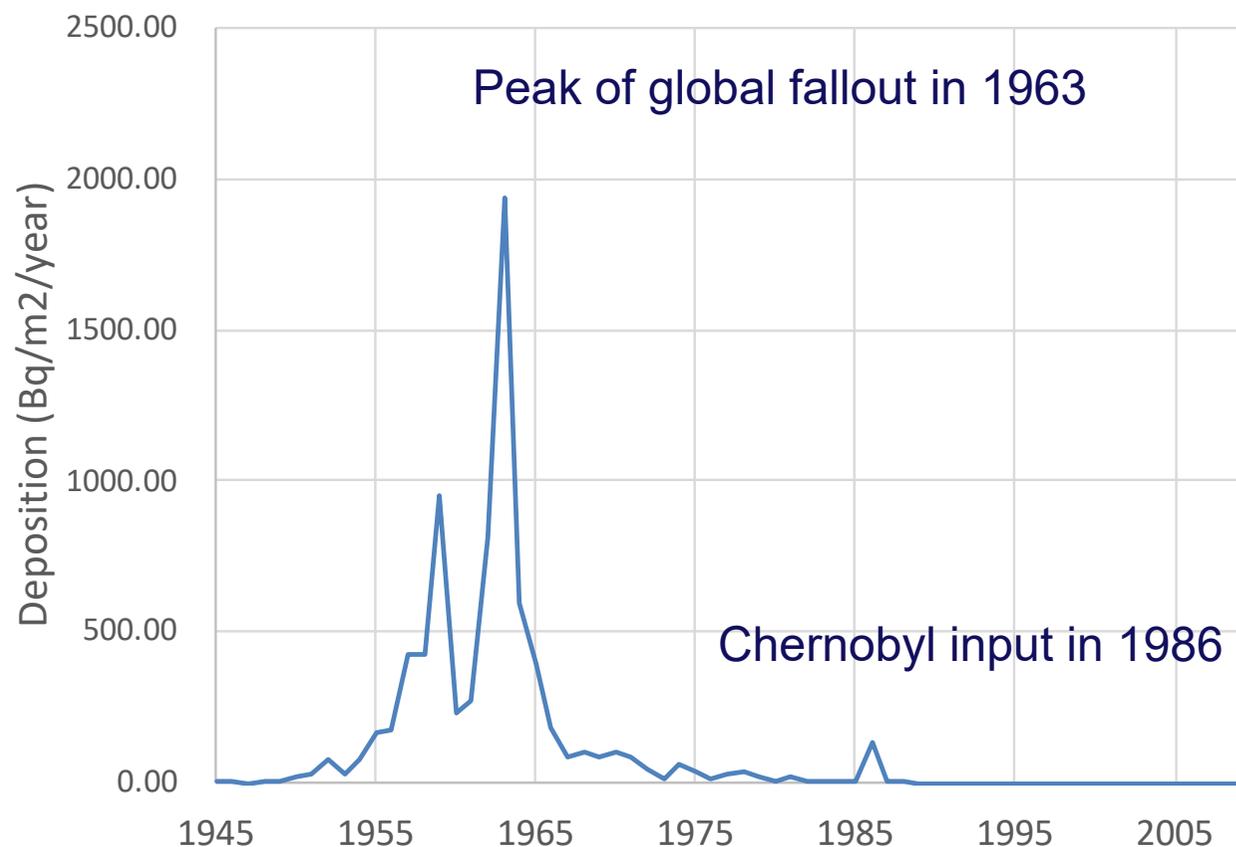
Objective

- ◆ Although simulations of ^{137}Cs activity by OGCMs have been carried out previously, the input condition of ^{137}Cs still has large uncertainties due to a lack of observations of global fallout.
- ◆ The horizontal resolution of the previously available estimated global fallout of ^{137}Cs was 10-degree longitude x latitude.
- ◆ We have produced a new estimate of the global fallout of ^{137}Cs with 2.5-degree resolution using the Global Precipitation Climatology Project (GPCP) data, and investigated the impact of the revised input condition on the simulation of distribution of ^{137}Cs in the ocean.

Method (Model)

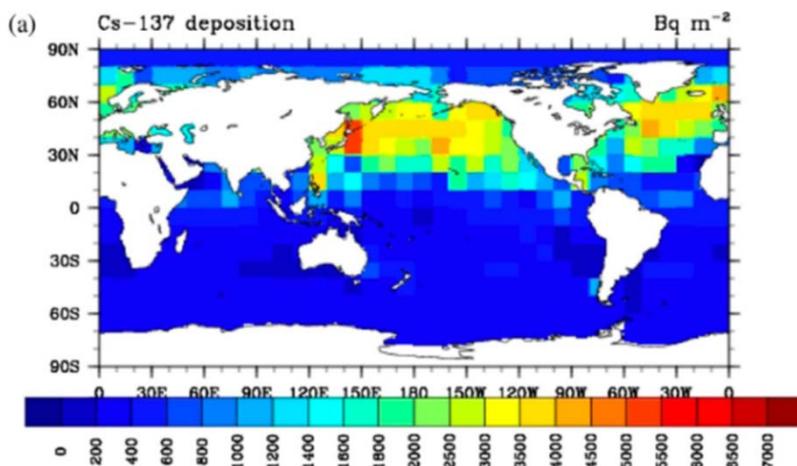
- ◆ Parallel Ocean Program version 2 (POP2) of the Community Earth System Model version 2 (CESM2).
- ◆ The horizontal resolution is 1.125 degree of longitude, and from 0.28 degree to 0.54 degree of latitude.
- ◆ There are 60 vertical levels with a minimum spacing of 10 m near the ocean surface, and increased spacing with depth to a maximum of 250 m.
- ◆ The simulated period was from 1945 to 2010 with the circulation forced by repeating (“Normal Year”) atmospheric conditions.

Method (^{137}Cs input)

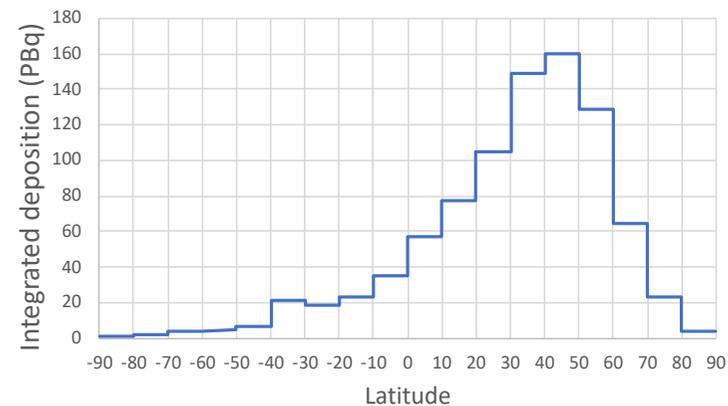


Temporal change of ^{137}Cs deposition ($\text{Bq/m}^2/\text{year}$) at the site of MRI, Japan

Method (^{137}Cs input)



Cumulative ^{137}Cs deposition ($10^\circ \times 10^\circ$) in 1970 constructed by observed data (Aoyama et al., 2006).



Meridional distribution of zonal cumulative ^{137}Cs deposition in 1970 constructed by observed data (Aoyama et al., 2006).

Horizontal resolution was too large in previous study (Tsumune et al., 2011)

Method (¹³⁷Cs input)

$$F(\lambda, \phi, t) = F_0(t) \frac{P(\lambda, \phi)}{P_0(t)} \varepsilon(\phi),$$

$F(\lambda, \phi, t)$: the estimated annual deposition (Bq/m²/yr)

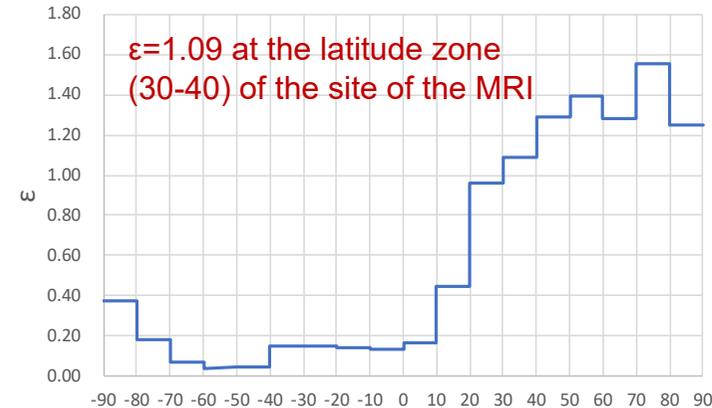
λ, ϕ : longitude, latitude t :time

$F_0(t)$: Observed annual deposition (Bq/m²/yr) on a reference site of MRI at 36° latitude

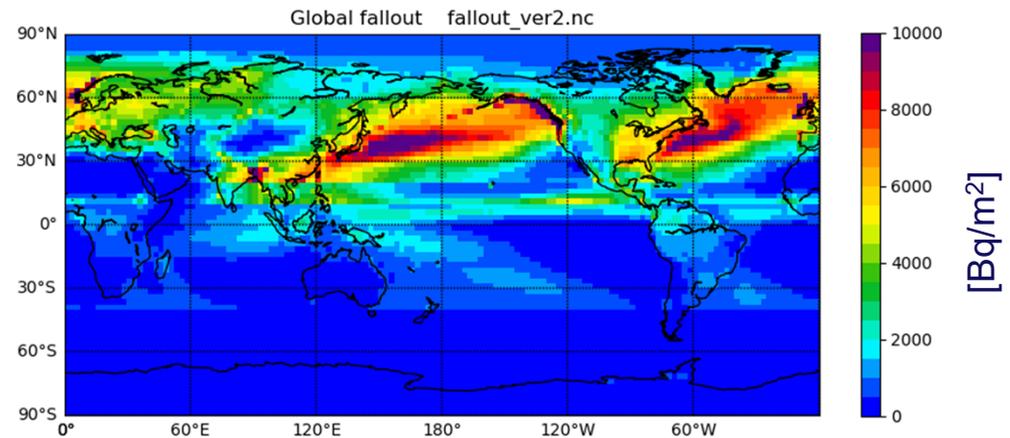
$P(\lambda, \phi)$: Annual precipitation(mm/yr) by the GPCP climatological data (2.5° x2.5°)

$P_0(t)$: Observed precipitation (mm/yr) on a reference site

$\varepsilon(\phi)$: Empirical function of the meridional distribution to fit the meridional distribution of zonal cumulative ¹³⁷Cs deposition in 1970 constructed by observed data (Aoyama et al., 2006).

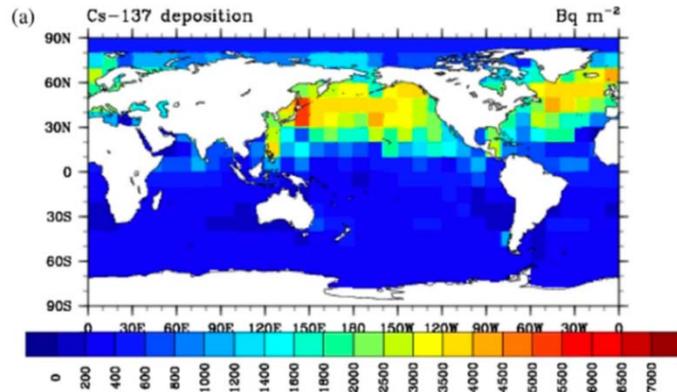


ε values in each 10 degree latitude to optimize the Integrated cumulative ¹³⁷Cs deposition.

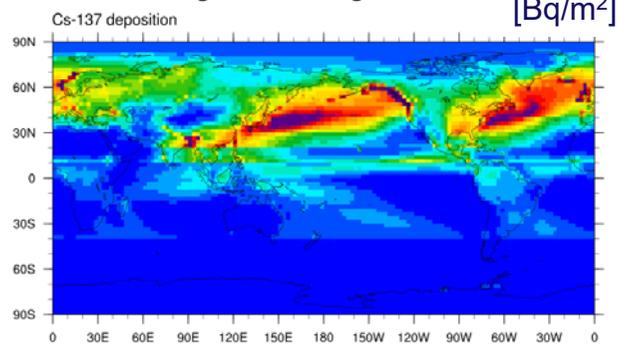


Cumulative ¹³⁷Cs deposition by 1970 (Bq/m²) with optimization of integrated cumulative ¹³⁷Cs deposition

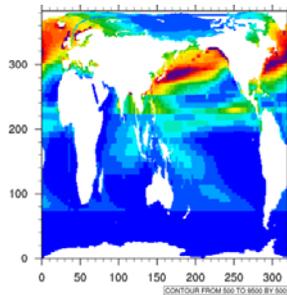
Method (^{137}Cs input)



Original rectilinear grid: 72 x 144



$[\text{Bq/m}^2]$



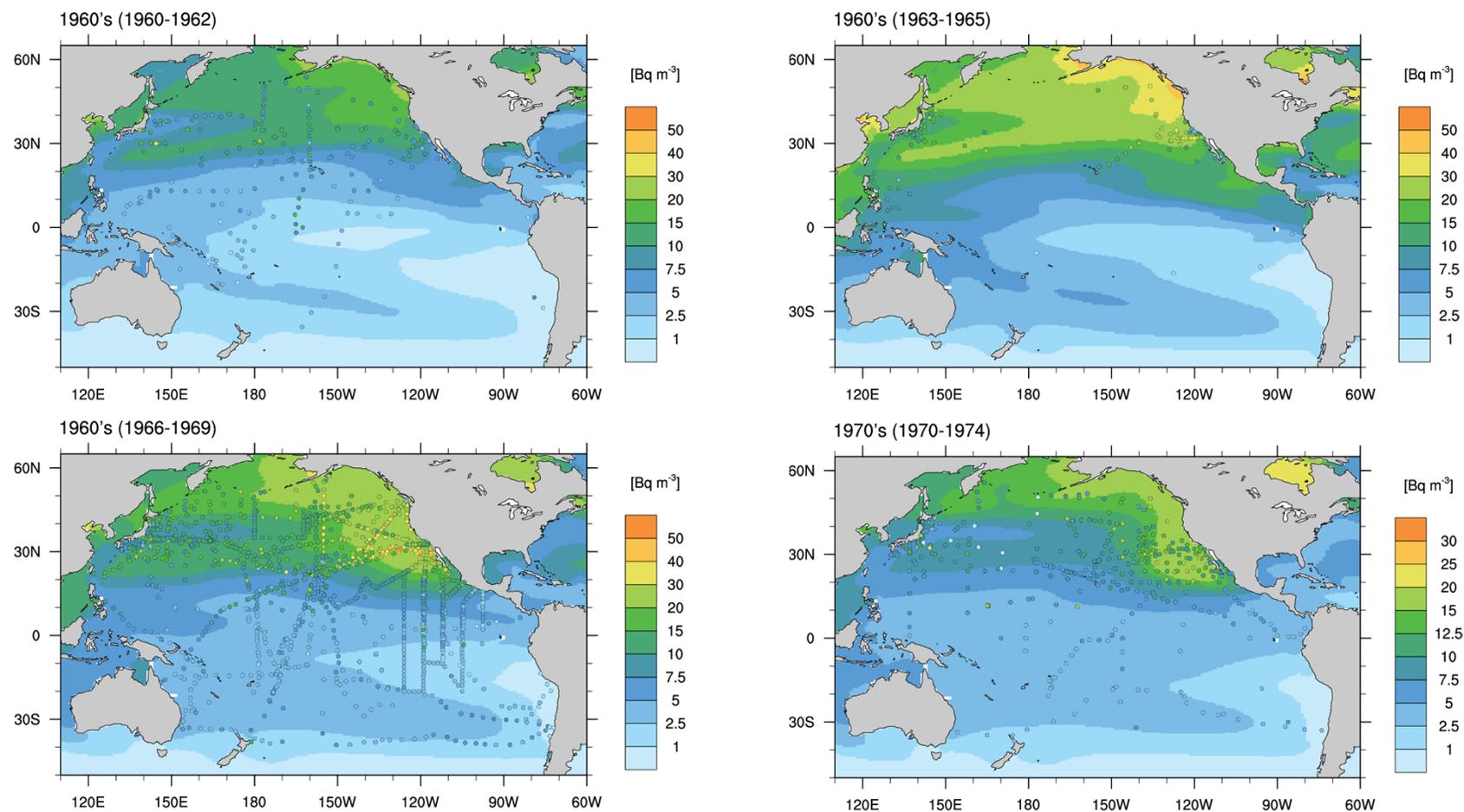
Zonal integrated cumulative ^{137}Cs depositions latitude are same in global.

Cumulative deposition in the ocean by 2010(PBq)

	Old	New	New/Old
Global ocean	809	637	0.79
North Pacific	436	347	0.80
North Atlantic	187	169	0.90

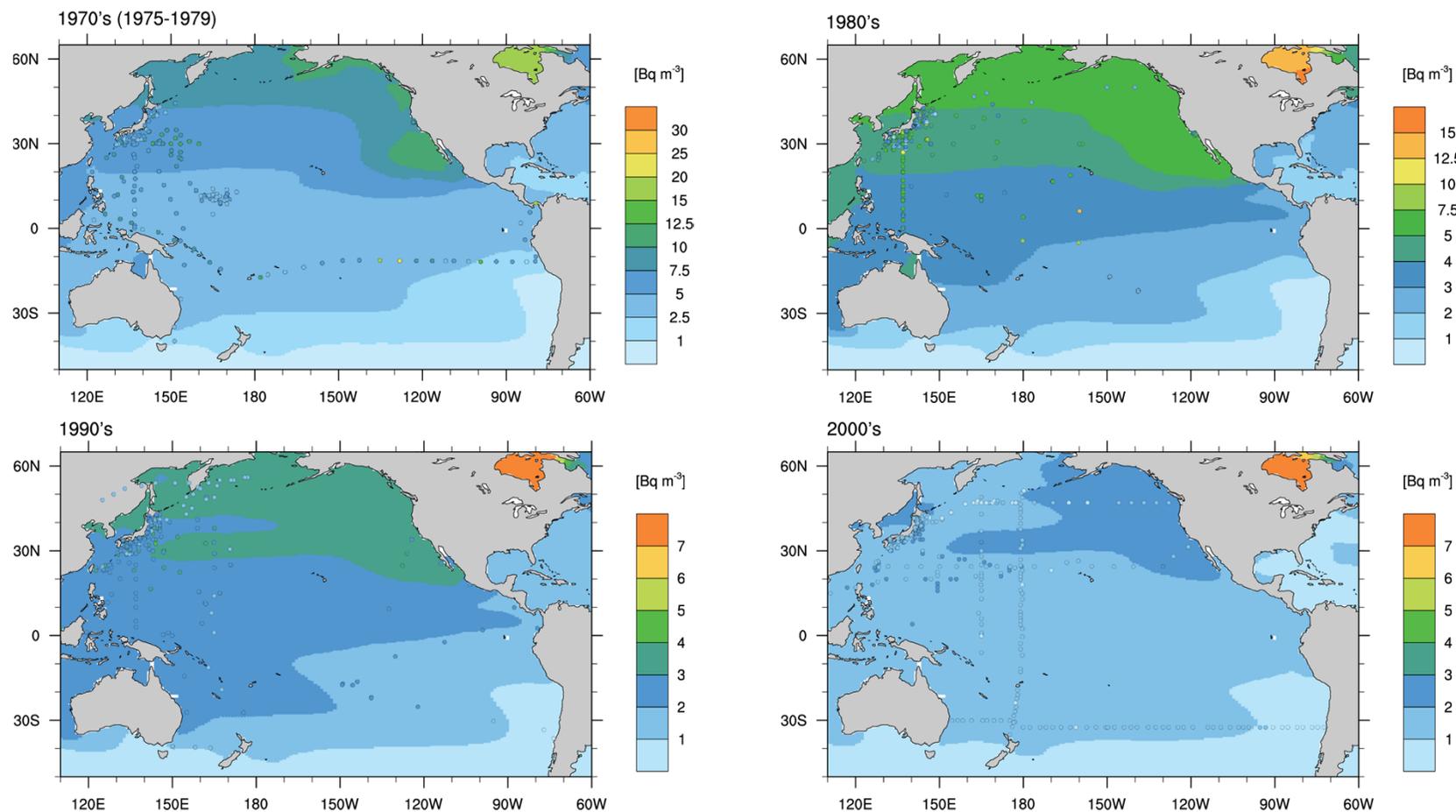
- ✓ Total amount of new cumulative deposition of ^{137}Cs is smaller than old one
- ✓ Distribution patterns are different, variable

Results (Global fallout)



Horizontal distribution of surface ^{137}Cs concentration
 Simulated ^{137}Cs distribution is in good agreement with observation

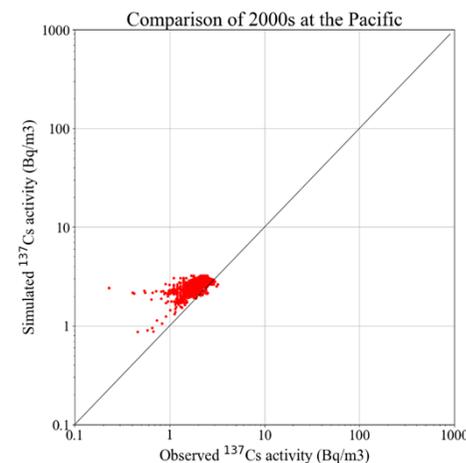
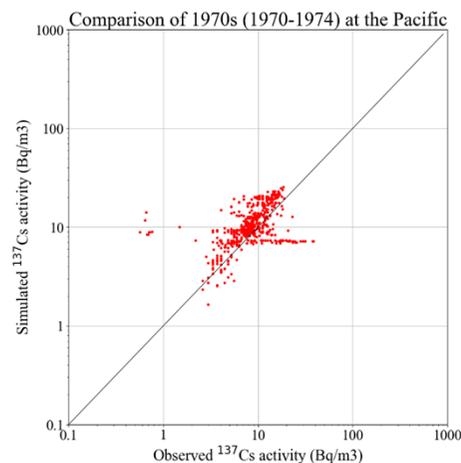
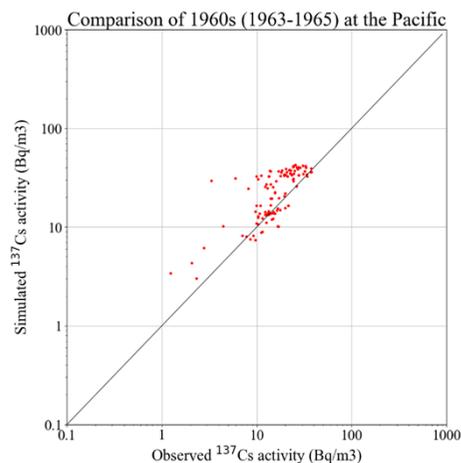
Results (Global fallout)



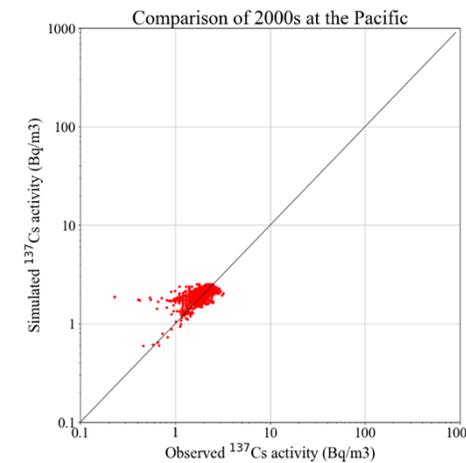
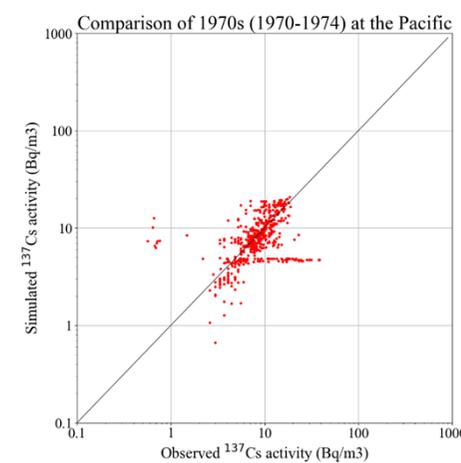
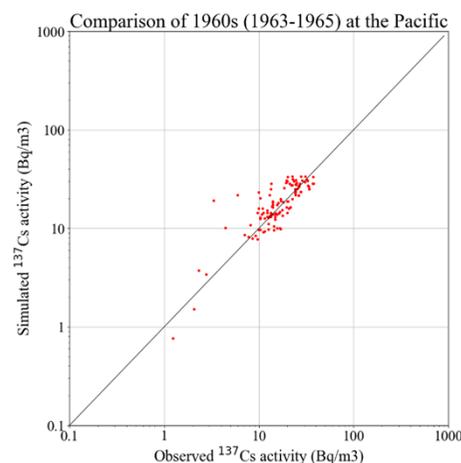
Horizontal distribution of surface ^{137}Cs concentration
 Simulated ^{137}Cs distribution is in good agreement with observation

Results (Global fallout)

Old
Deposition



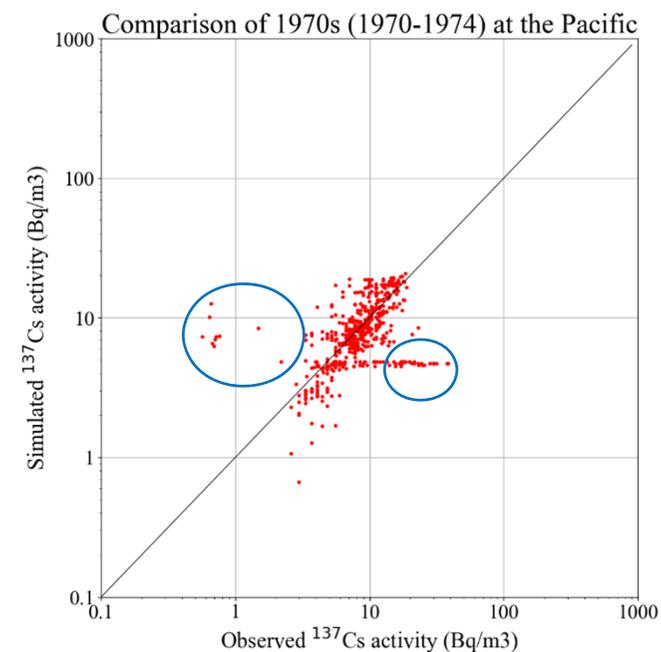
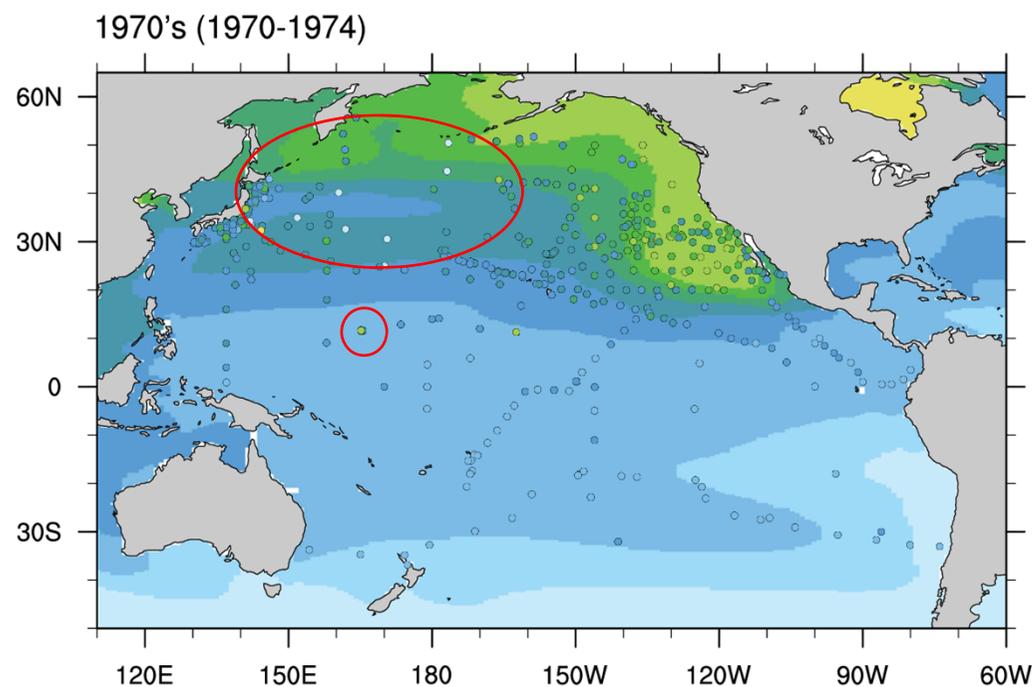
New
Deposition



Comparison between simulation and observation

- ✓ New distribution of ^{137}Cs deposition improved reproducibility of observed ^{137}Cs distribution

Results (Global fallout)



- Simulation can help to check the database.
 - Mistake of unit conversion
 - High activity in the Nuclear weapons test site

Summary

- ◆ We have simulated ^{137}Cs activity derived from the atmospheric weapons tests by an OGCM from 1945 to 2010.
- ◆ We have estimated new deposition data with higher resolution.
- ◆ New distribution of ^{137}Cs deposition improved reproducibility of observed ^{137}Cs distribution.
- ◆ Comparison between observation and simulation provided useful information to understand the phenomena in the interpretation of sparse observations and find the error in the database.