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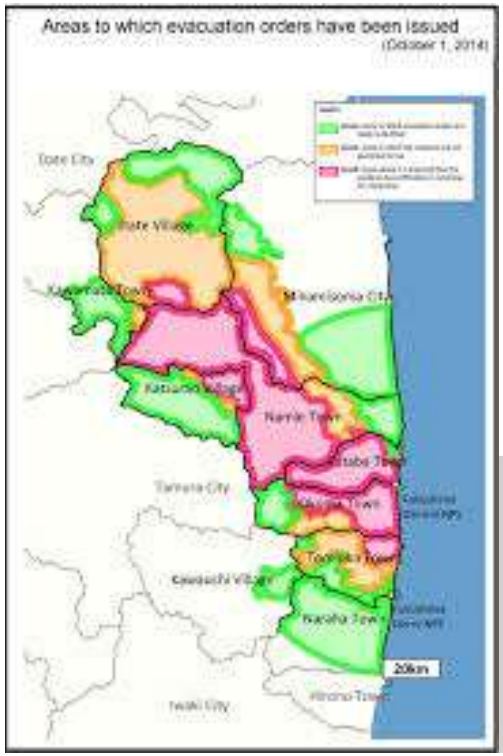
福島の避難区域の環境放射能…何が起きているか？

What is happening to radioactivity in the environment of the Fukushima exclusion zone?



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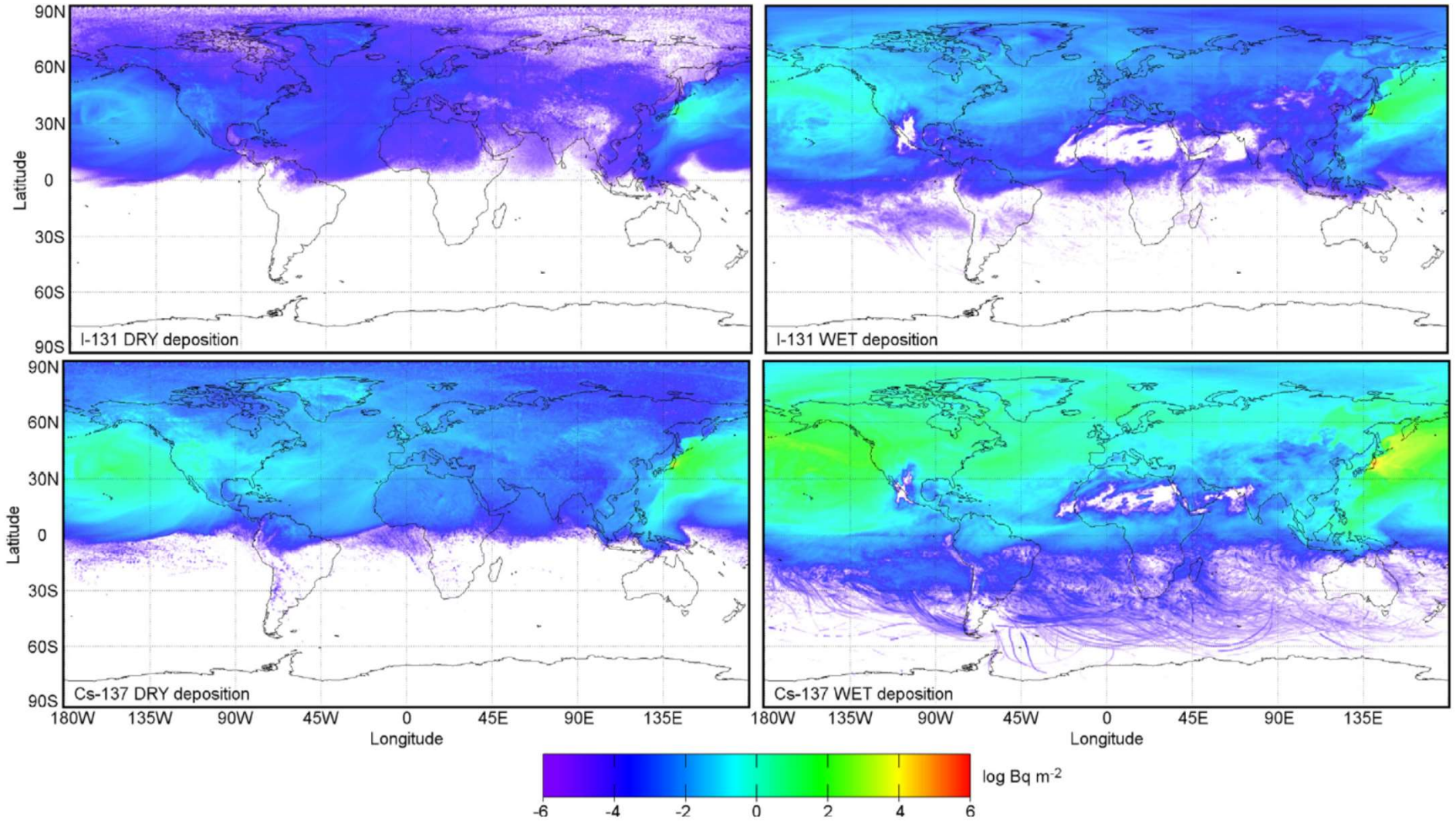
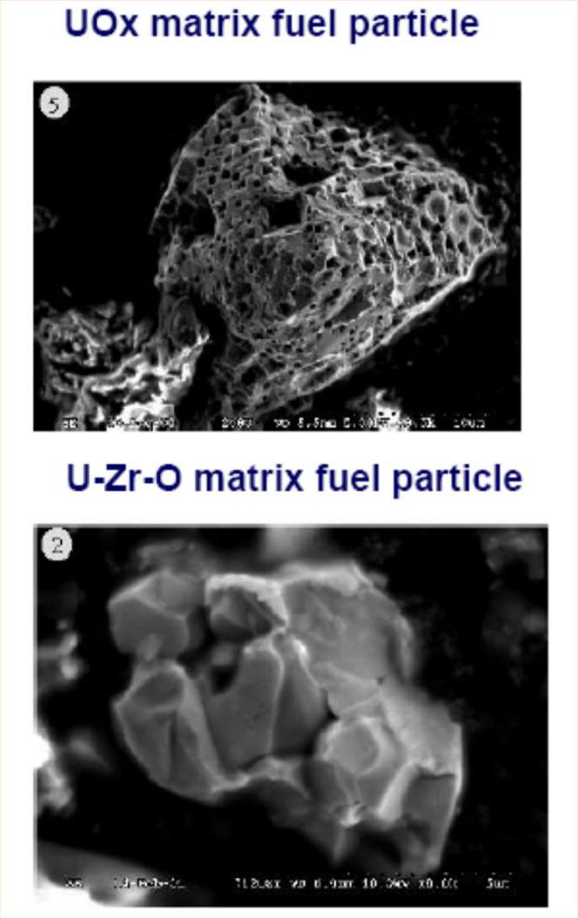
Worldwide ^{131}I and ^{137}Cs deposition



After Marzo, 2014

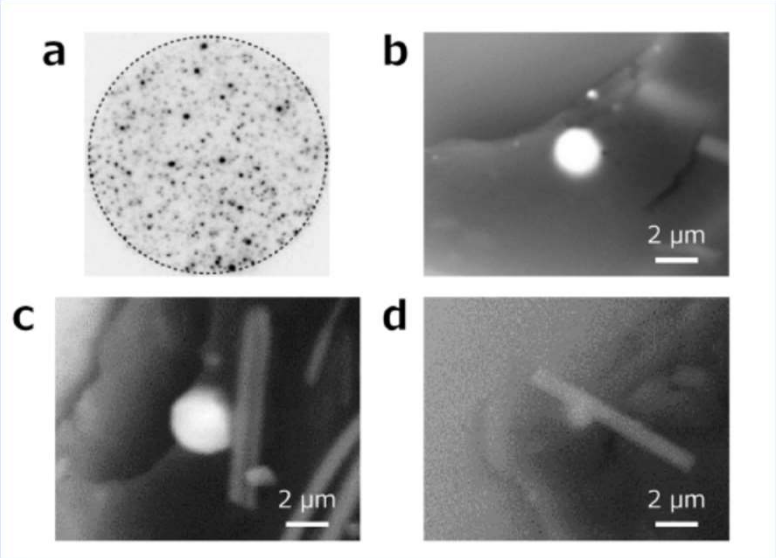
堆積における初期r-Cs化学形態
Initial r-Cs chemical forms in the fallout

Chernobyl: **insoluble fuel and soluble condensation particles**



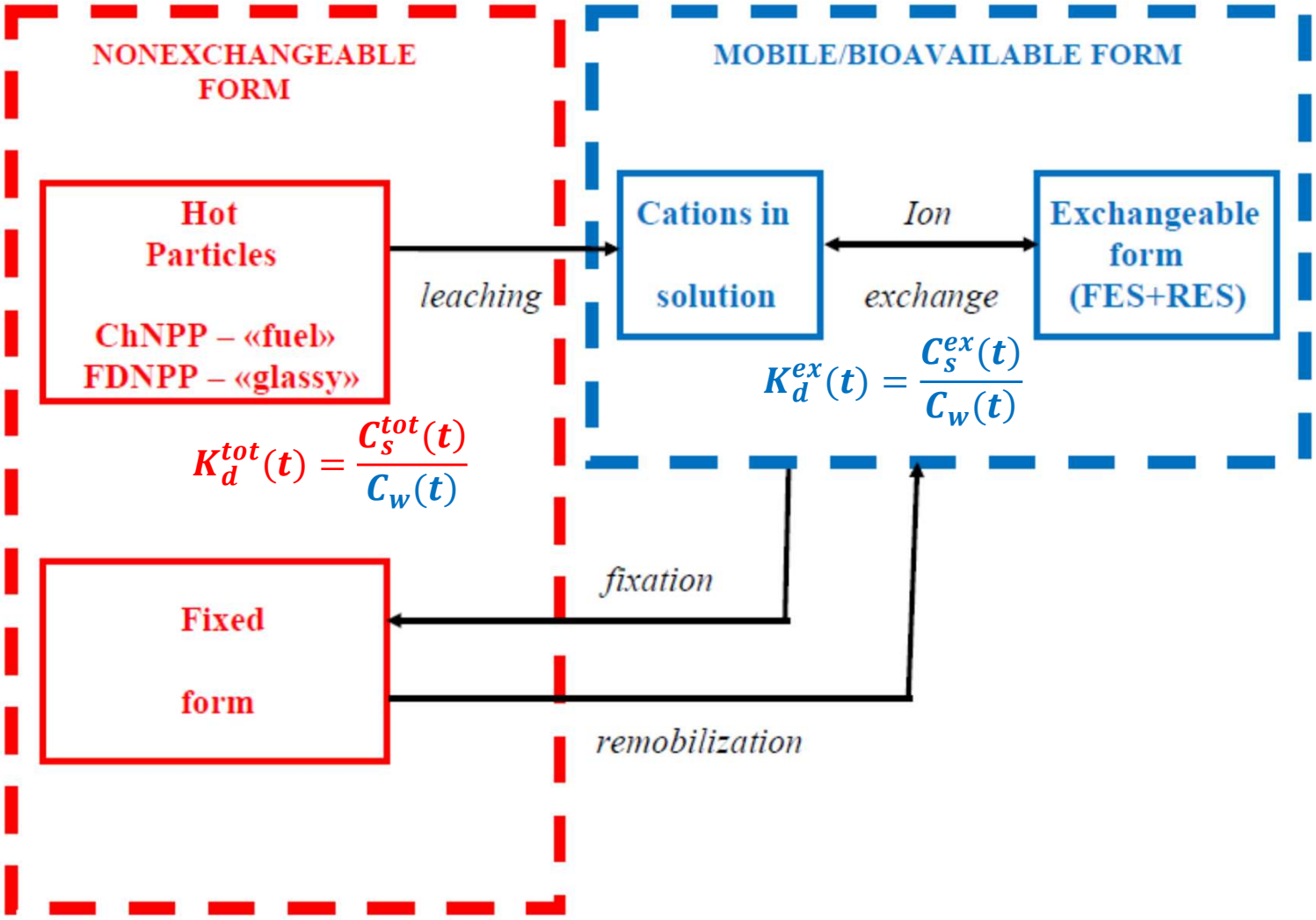
After **Salbu**, 1996

Fukushima: **soluble condensation particles, but also insoluble glassy hot particles – "Cs balls": 48-318 particles per g soil; 8.5-32% of radioactivity (Ikehara et al., 2018)**

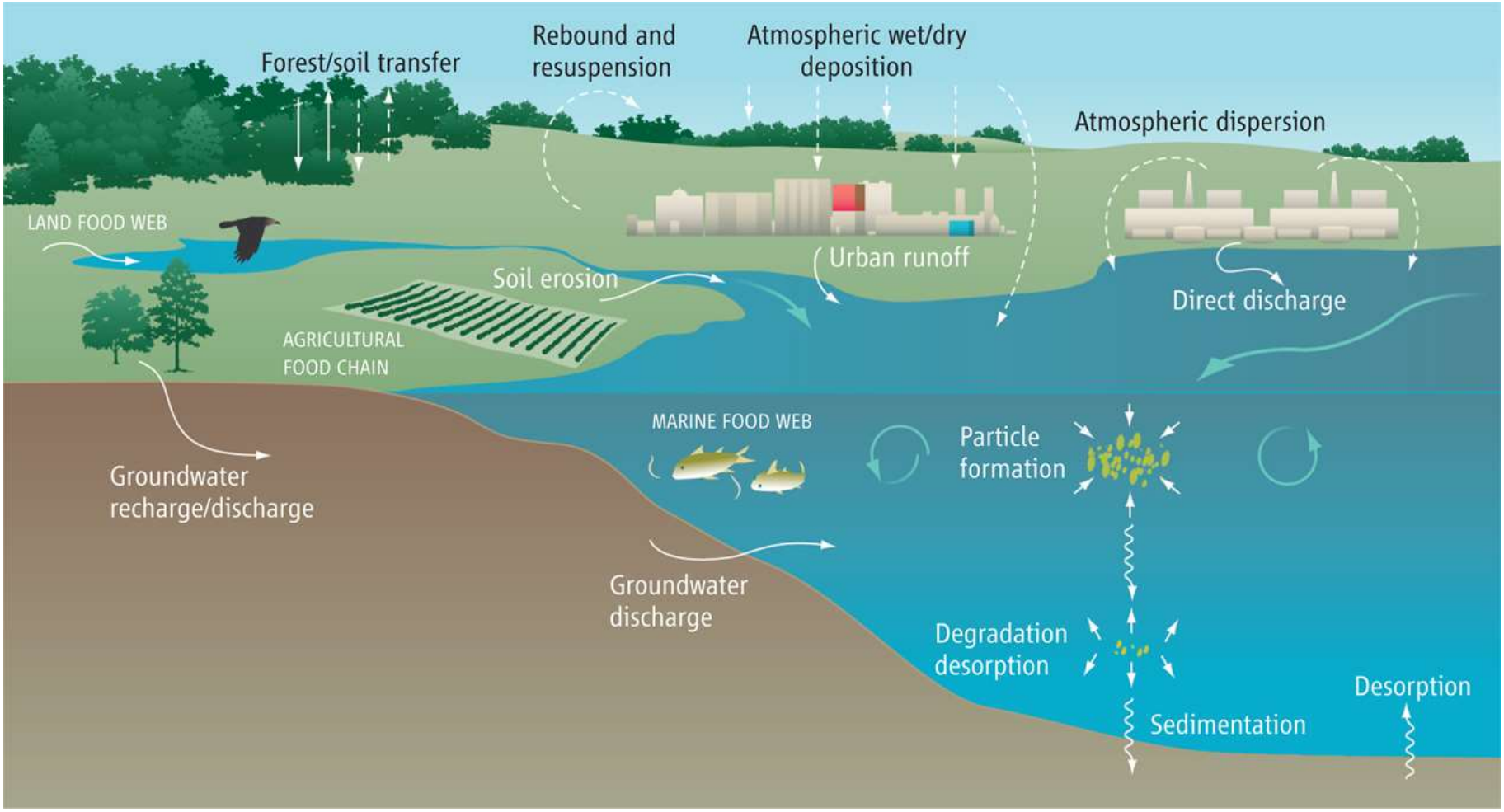


After **Abe, Adachi** et al., 2014

土壌・堆積物中のr-Cs保持の概念モデルとその化学形態の変換
Conceptual model of r-Cs retention in soils and sediments and transformation of its chemical forms



誤って放出された放射性核種の環境中での運命と輸送
Fate and transport of accidentally released radionuclides in the environment



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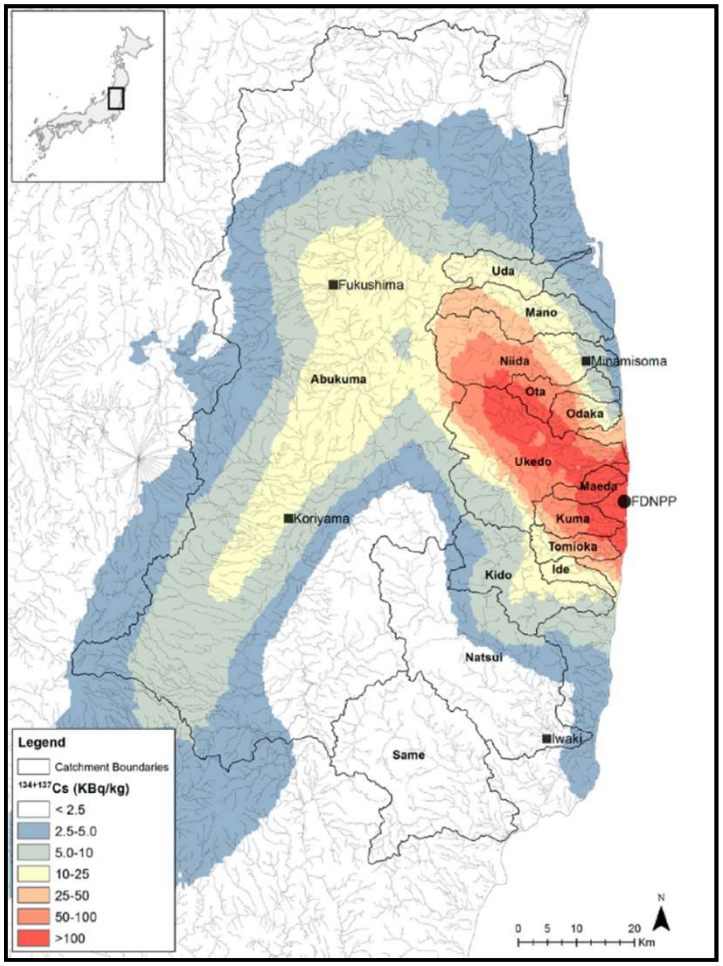
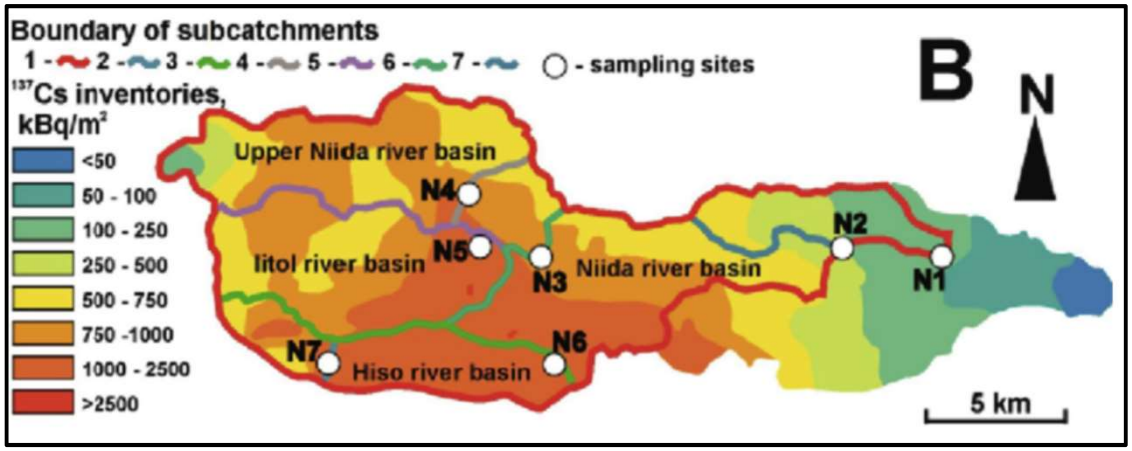
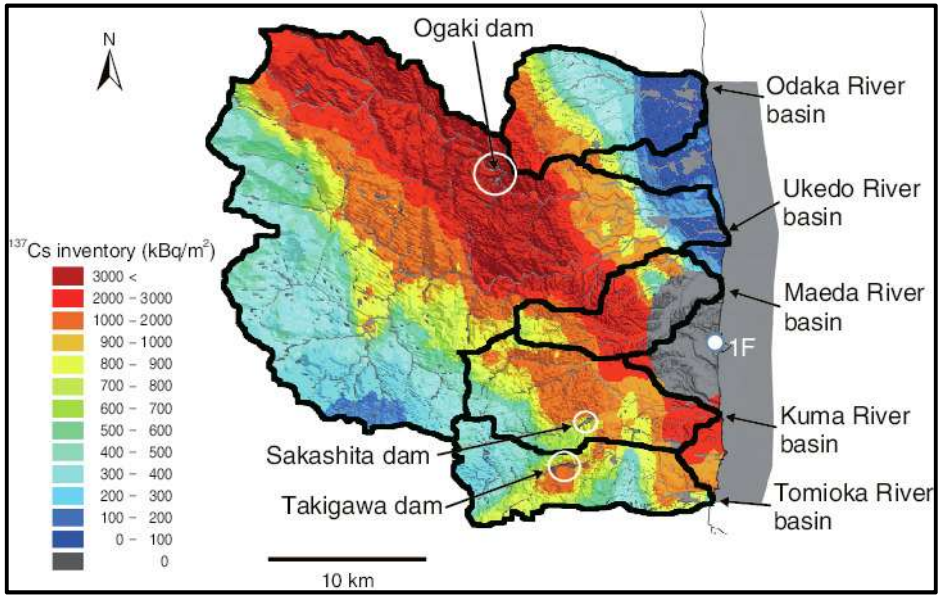
Study areas and observation sites in Fukushima Exclusion Zone

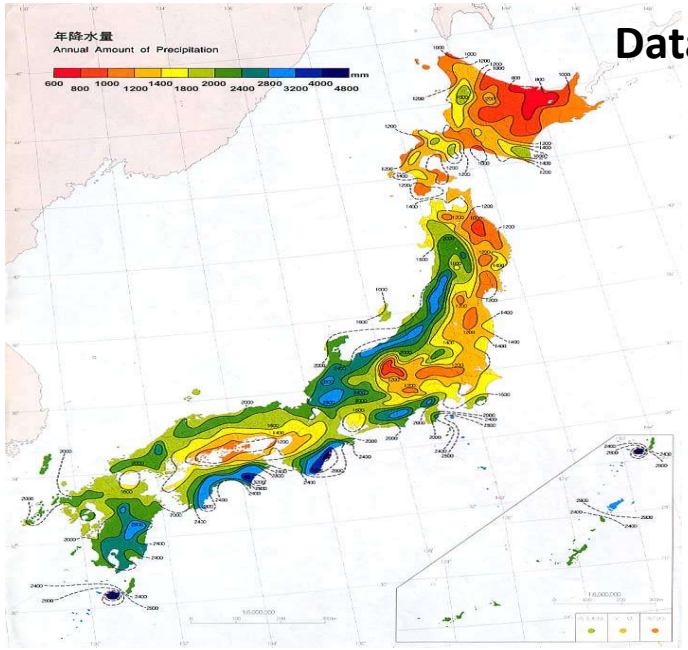




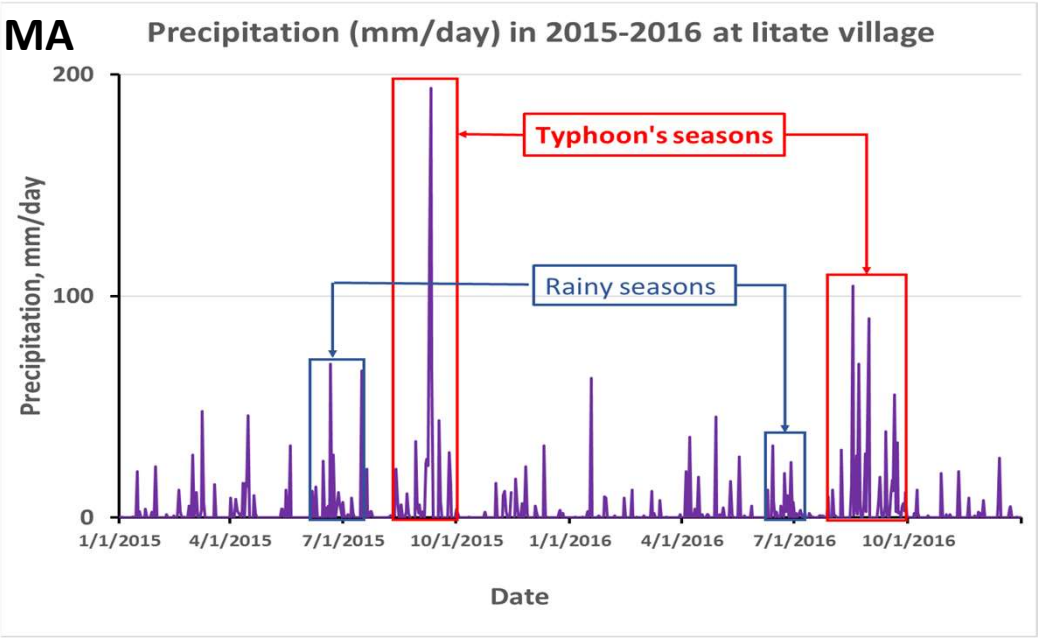


Rivers: Abukuma, Niida, Maeda
Dam Reservoirs: Sakashita, Yokokawa
Ponds: Inkyozaka, Suzuuchi, Funasawa, Kashiramori (Okuma);
Shimofukazawa, Biwa (Futaba)

福島の流域からの放射性セシウムの流出
Radiocesium wash-off from the catchments of Fukushima



Data of JMA



Mean annual precipitation at 5 meteo-stations in Fukushima Exclusion Zone, mm

Haramachi	Namie	Iitate	Tsushima	Tomioka
1380±190	1490±200	1310±190	1450±160	1590±70

Generally, relatively high precipitation, air temperatures and steep slopes in the region promote higher wash-off of radiocesium and relatively fast natural attenuation.

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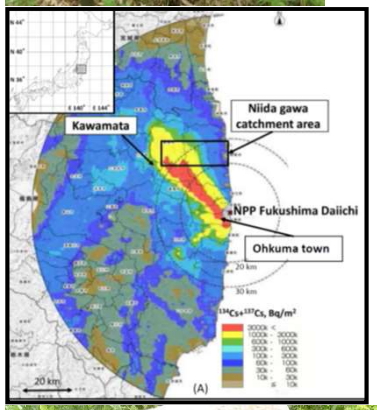
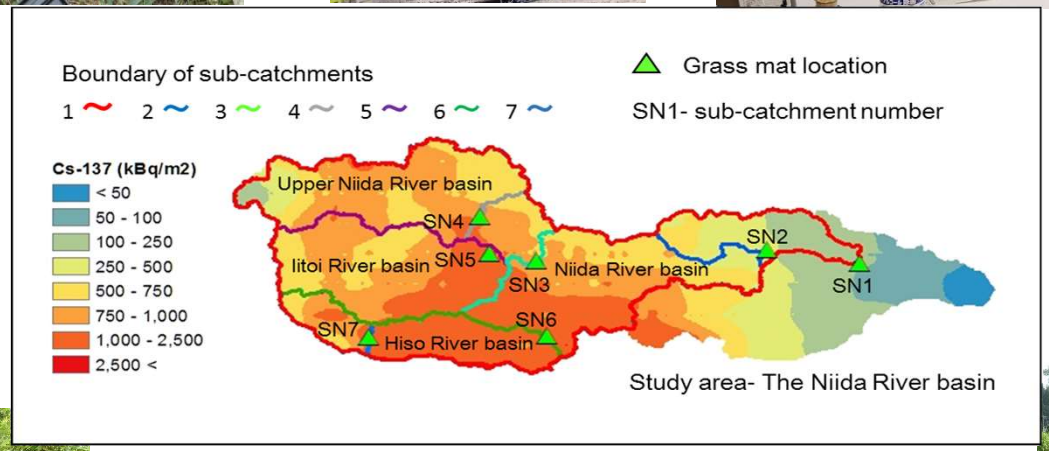
Niida River: R-Cs vertical distribution on floodplain – accumulation and loss





Grass matts installation for sediments collection

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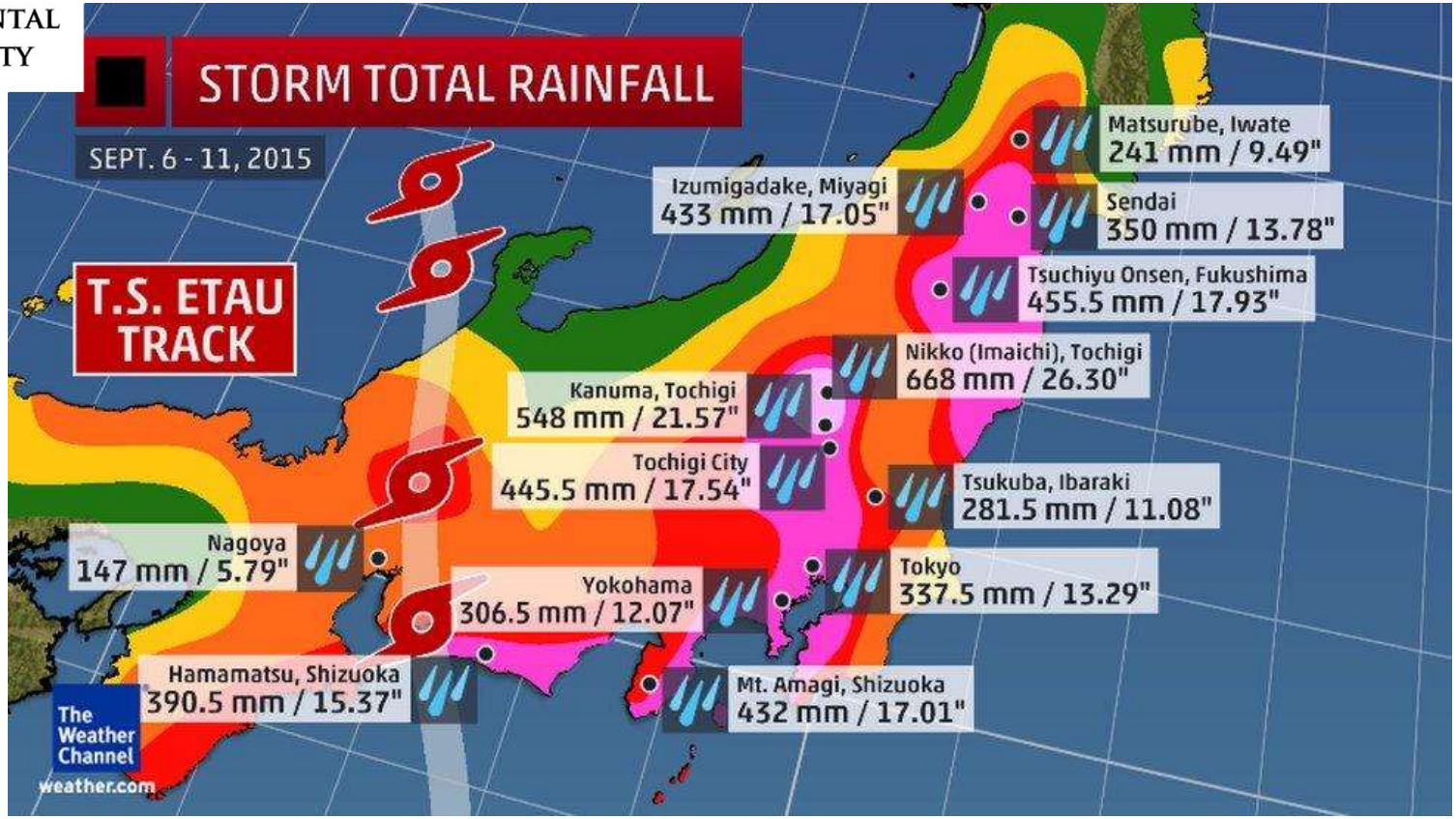

Extreme floods during tropical storms as a factor of sediments redistribution and natural decontamination

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Natural attenuation due to extreme flood events in Fukushima

N6: During several days of extreme flood in September 2015 accumulation of sediments occurred for 35-40 cm

Dose rate at h=1 m:

Before 2015.9.16
6 µSv/h

After 2015.9.16
0,85 µSv/h

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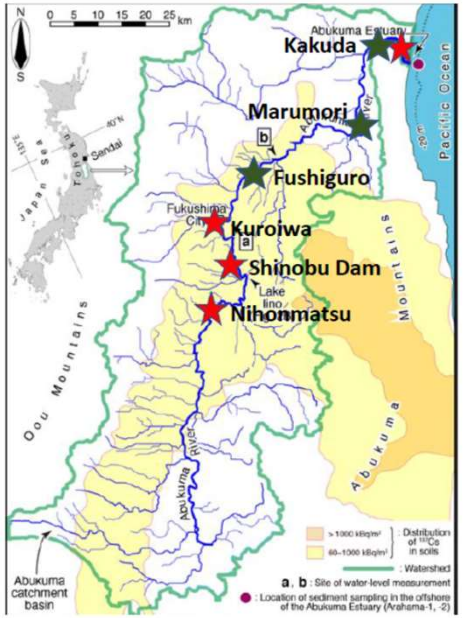

Fieldwork on Abukuma river in 2018

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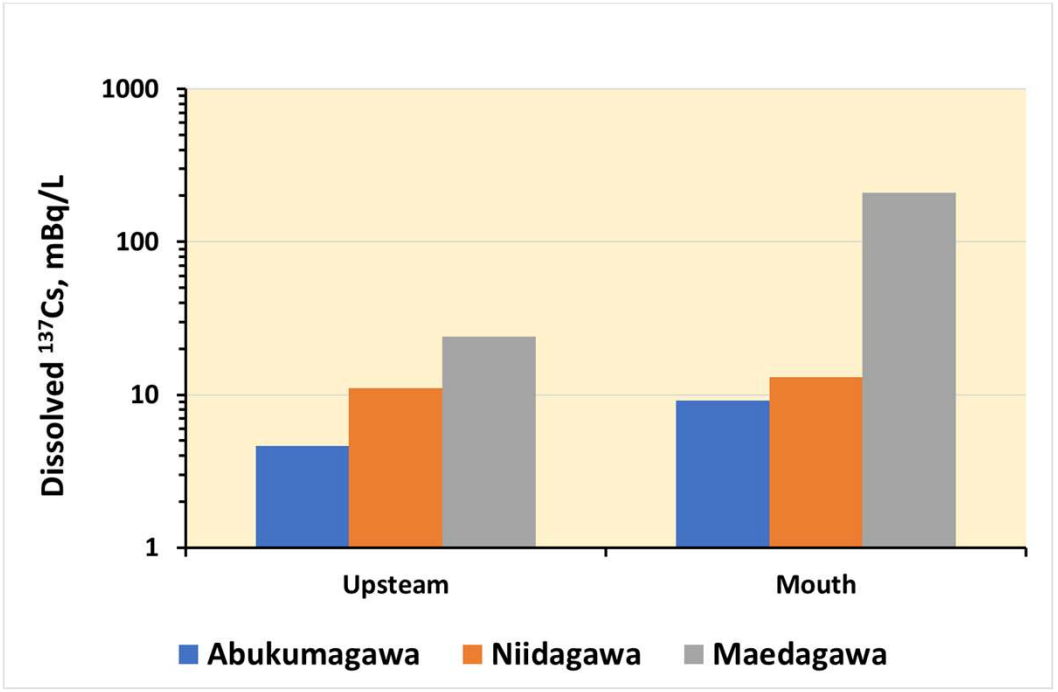
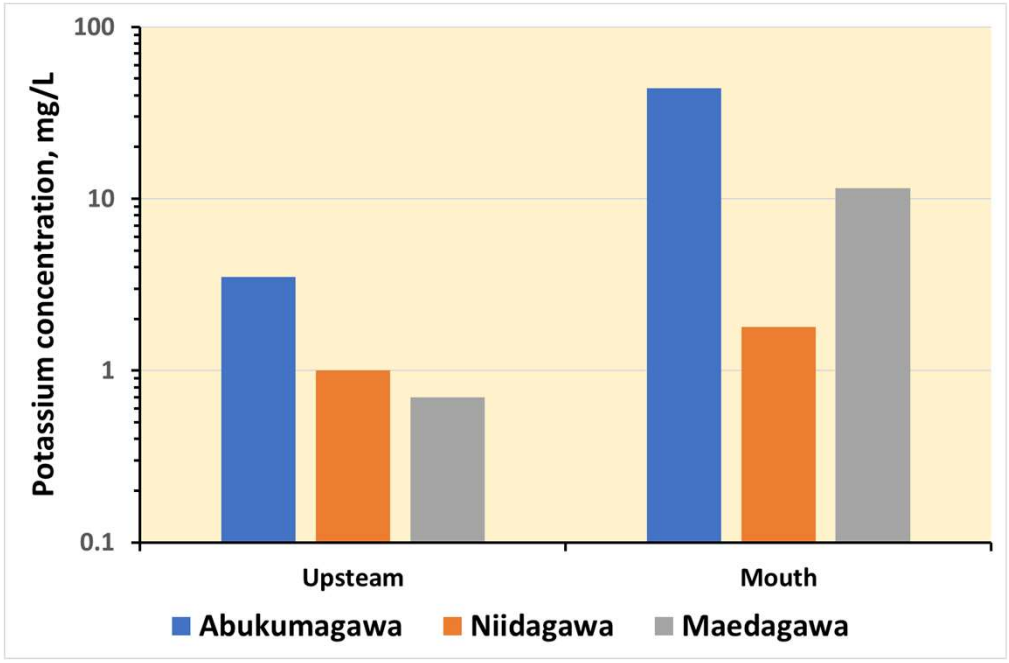
Changes in river hydrochemistry from upstream to the mouth cause r-Cs remobilization





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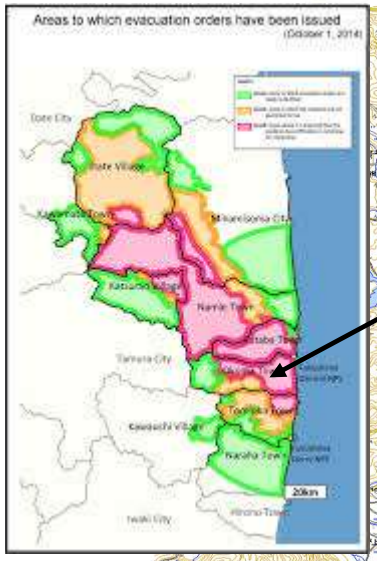
Irrigation ponds in close proximity of FDNPP (Konoplev et al., 2016; Wakiyama et al., 2017)



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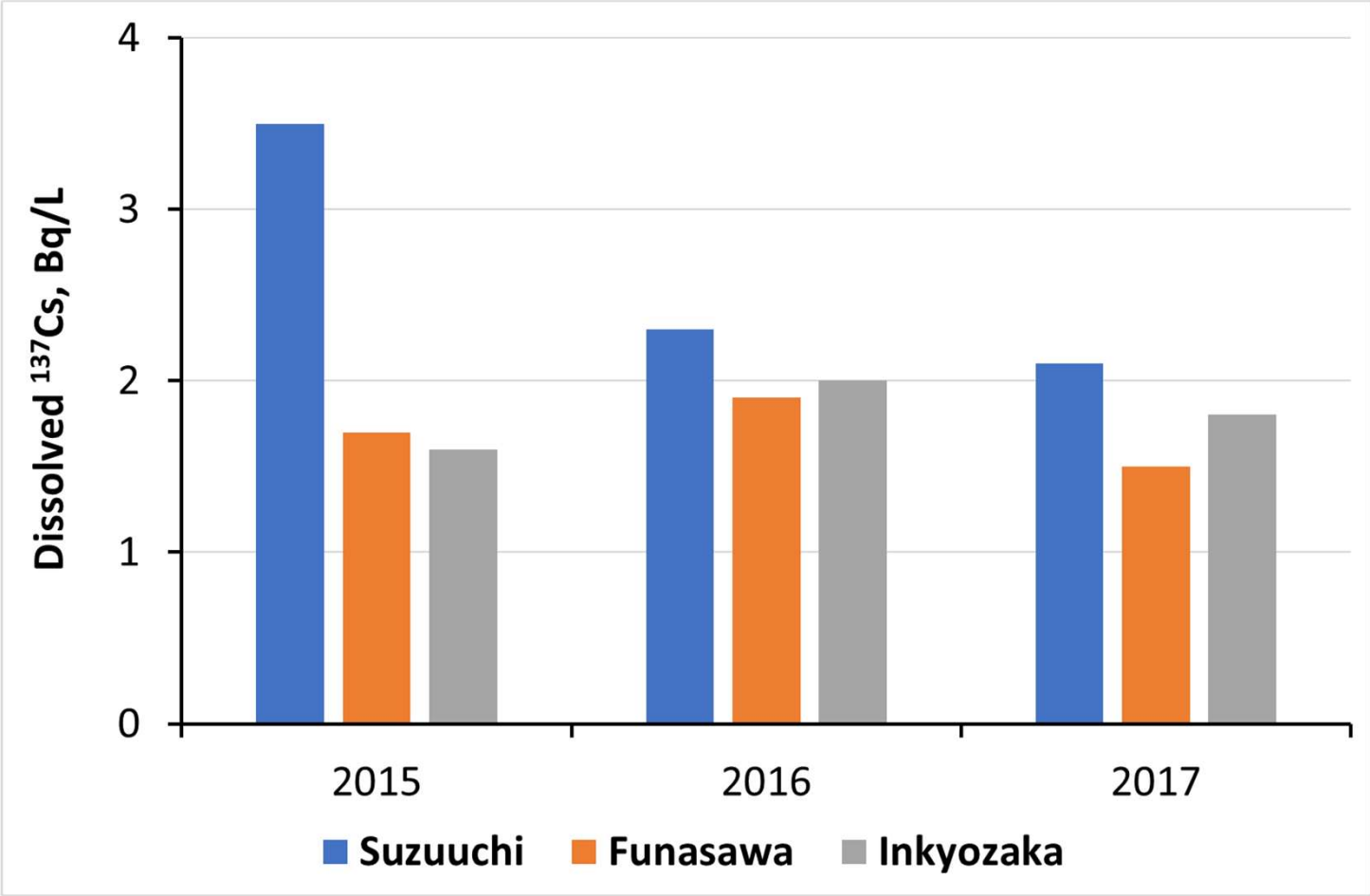
Dynamics of annual means of dissolved ^{137}Cs (Bq/L) in Okuma ponds



- **R-Cs activity concentrations in ponds are much higher as compared with rivers and dam reservoirs.**
- **R-Cs showed a persistent behavior in Okuma ponds: its activity concentrations were not decreasing.**

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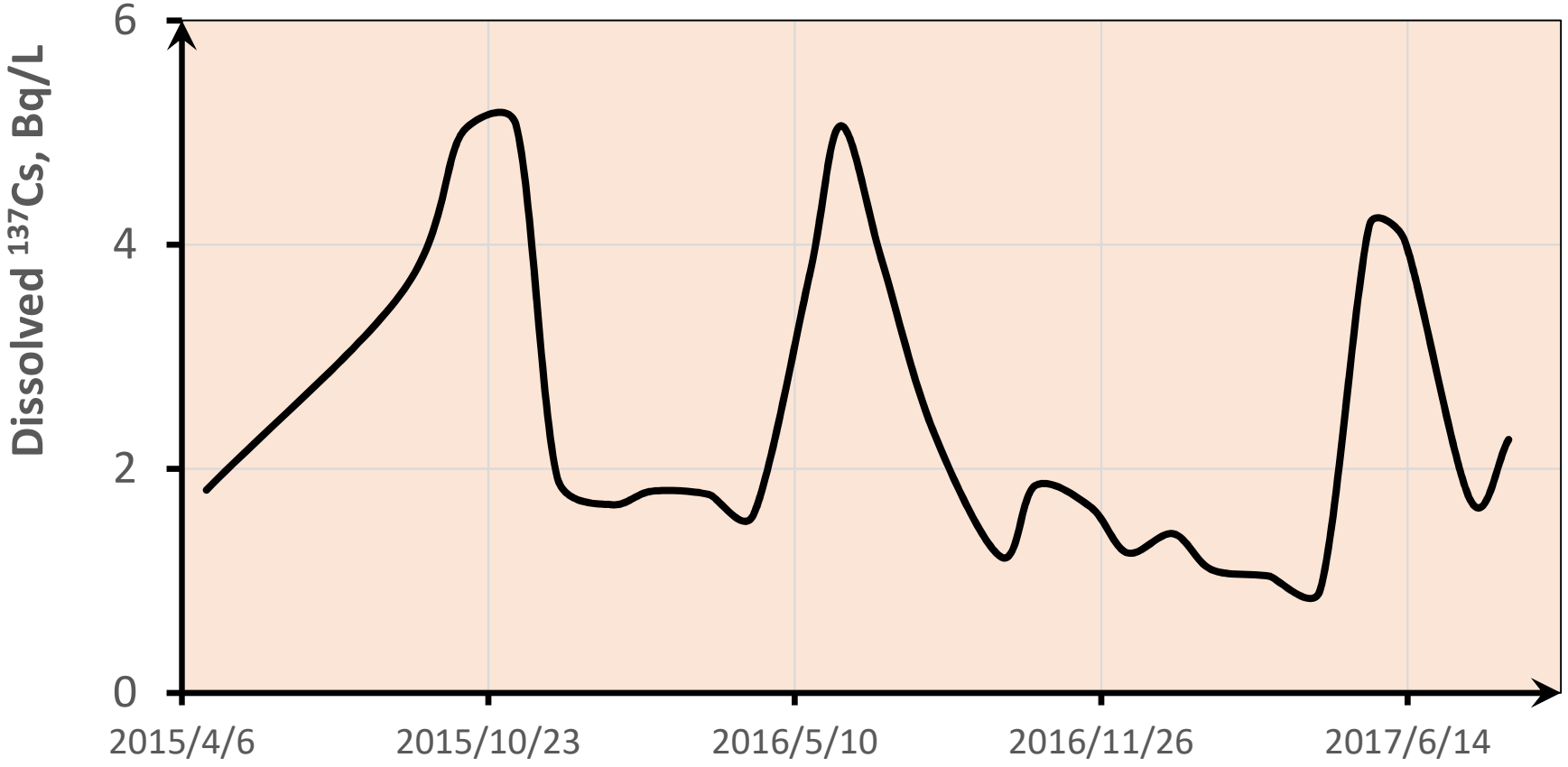
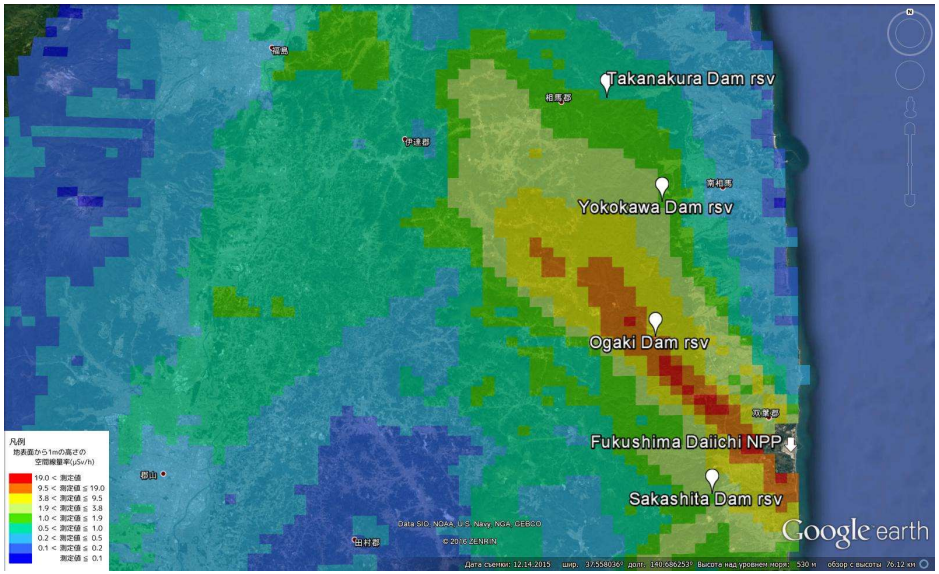
Regular seasonal variations of dissolved ^{137}Cs in Okuma ponds: ^{137}Cs concentrations tend to grow in the summer and decrease in the winter.

Dynamics of dissolved ^{137}Cs for Suzuuchi in 2015-2017

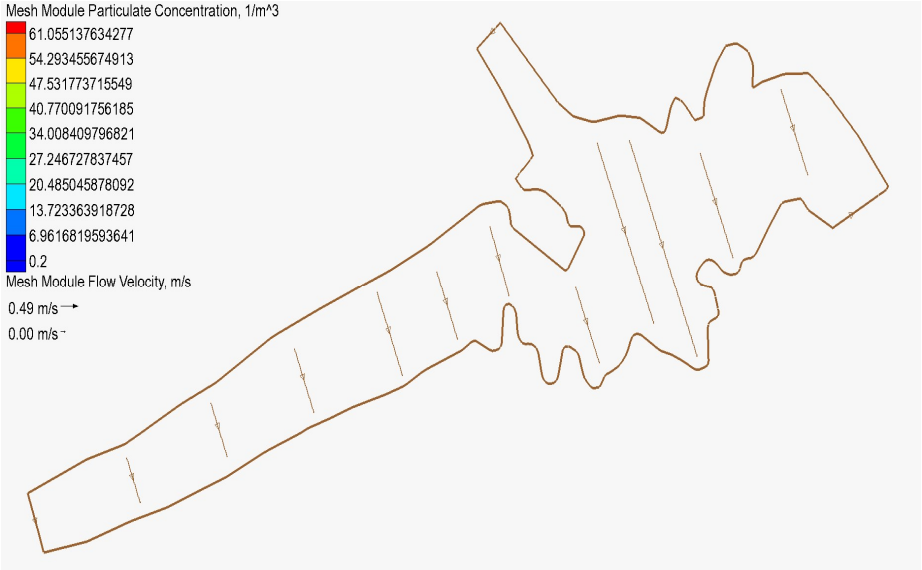


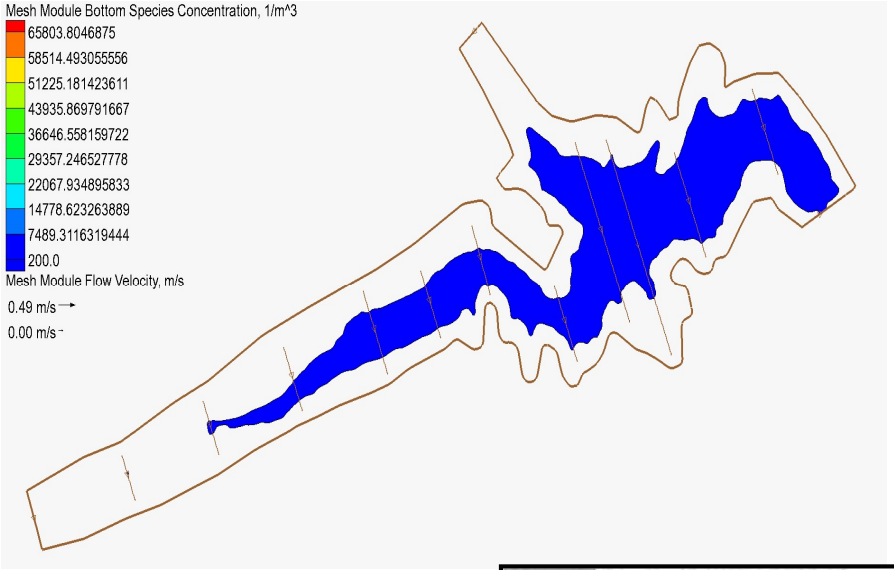
沈降は、水柱から底質への^{137}Cs除去の主要な自然減衰プロセスである
Sedimentation is a key natural attenuation process of ^{137}Cs removal from the water column to the bottom sediments



- There are deep reservoirs on many Fukushima rivers at Yokokawa Dam - Ota River, Takanokura Dam - Mizunashi River, at Ogaki Dam – Ukedo River, Sakashita Dam – Kuma River.
- These reservoirs in Fukushima area play a role of the "traps" for the contaminated sediments.

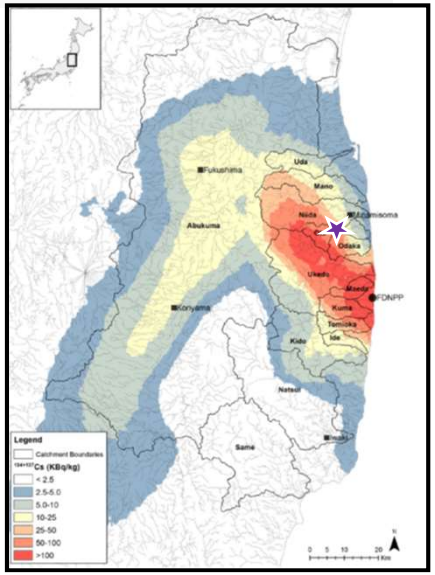
福島地域の横川ダムにおける粒子状r-Csトラップのモデリング
Modelling of particulate r-Cs trapping in Yokokawa dam of the Fukushima area (Zheleznyak & Kivva)





洪水中の：横川ダムの懸濁態Cs-137濃度（左）と底質堆積物の^{137}Cs堆積量（右）

Particulate ^{137}Cs concentration in water column (left) and ^{137}Cs deposition in bottom (right) of the Yokokawa reservoir during the high flood.



まとめ
Main messages

是正戦略の策定と意思決定のためには、長期的な大規模モニタリングプログラムを実施する必要があります。For remediation strategy development and decision making the long-term wide scale monitoring program should be in place;

福島由来のr-Csは土壌や堆積物の粒子に強く結びついています。これは、表流水中のr-Csのより速い掃去と、表面流出と河川流を伴う懸濁物質上のr-Csの優勢な輸送を促進する。Fukushima-derived r-Cs is strongly bound by soil and sediment particles. This promotes faster scavenging of r-Cs in surface waters and prevailing transport of r-Cs on suspended material with surface runoff and river flow;

福島の立ち入り禁止区域における比較的高い降水量、気温、急な斜面は放射性セシウムの著しい洗い流しと汚染された流域の自然な減衰を促進する。Relatively high precipitation, air temperature and steep slopes in Fukushima Exclusion Zone promote significant wash-off of radiocesium and natural attenuation of contaminated catchments;

台風時の極端な洪水は、福島県立排除区での放射能汚染の迅速かつ効率的な自己浄化をもたらします。Extreme flood events during typhoons result in fast and efficient self-purification of radioactive contamination in Fukushima Exclusion Zone.

ご清聴ありがとうございました！
Thank you very much for your attention!

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