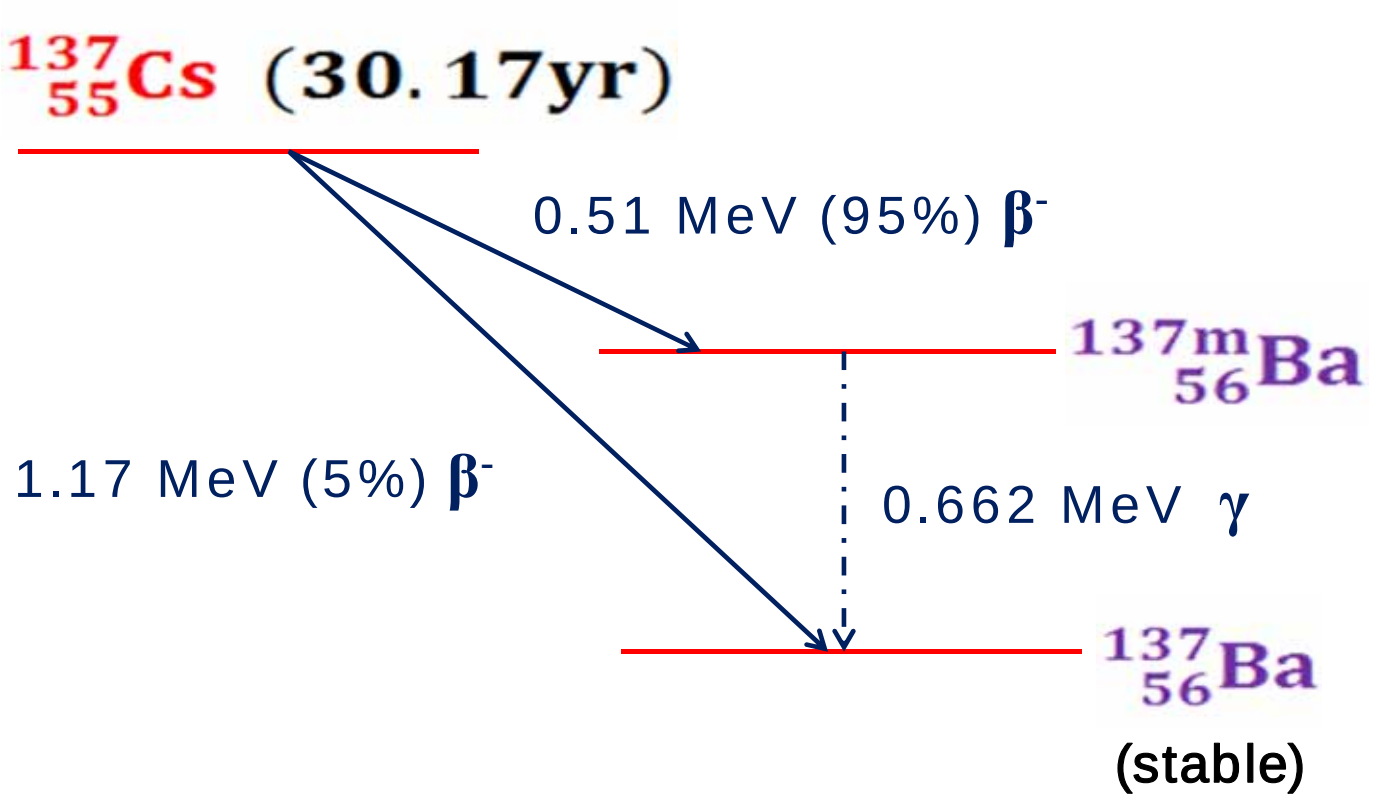
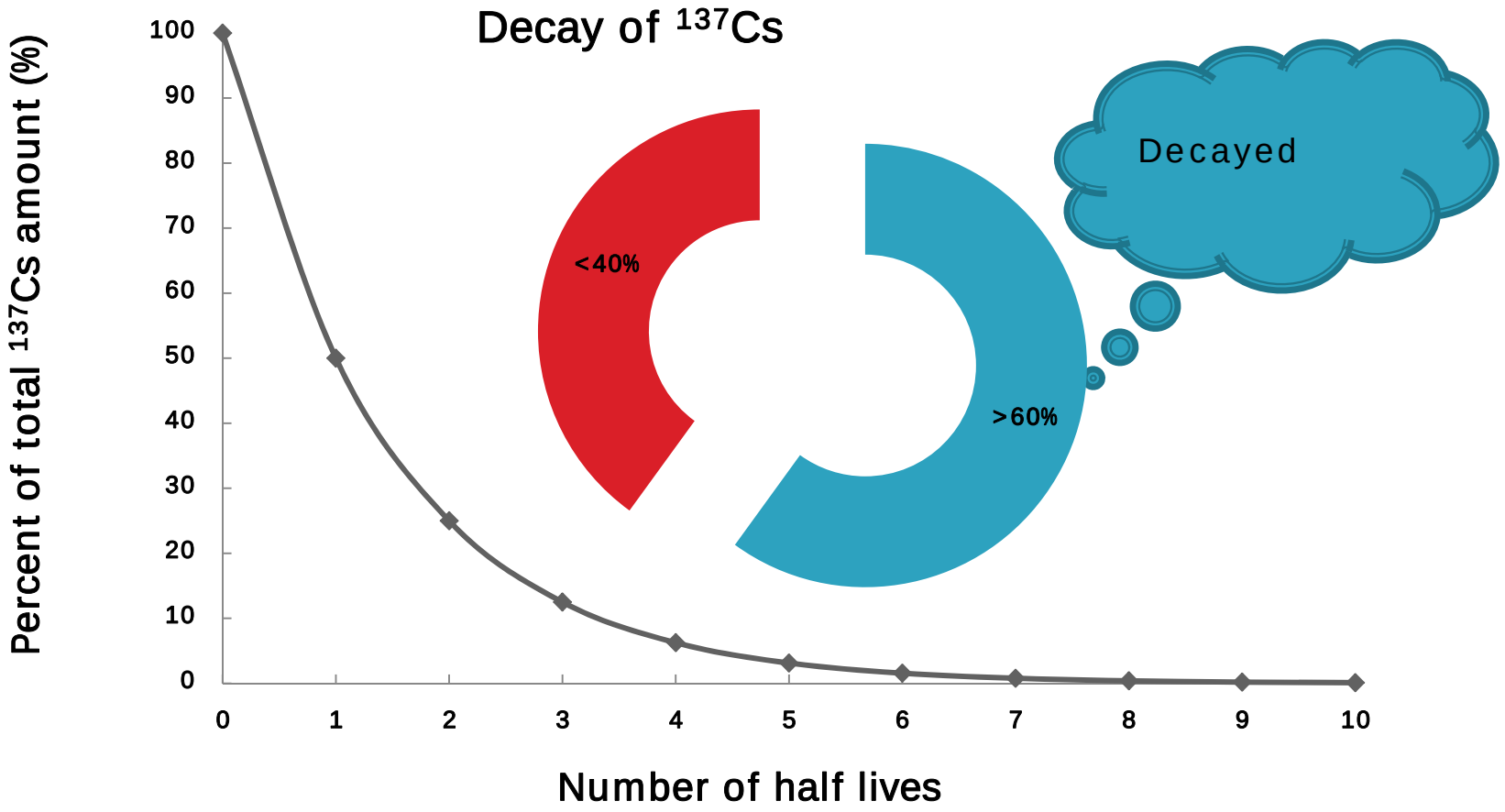
Could plutonium be a substitute of ^{137}Cs for tracing soil erosion?

Yihong Xu
DTU-Nutech;
Nanjing University, China
06-09-2013

◆The most widely used soil erosion tracer---^{137}Cs



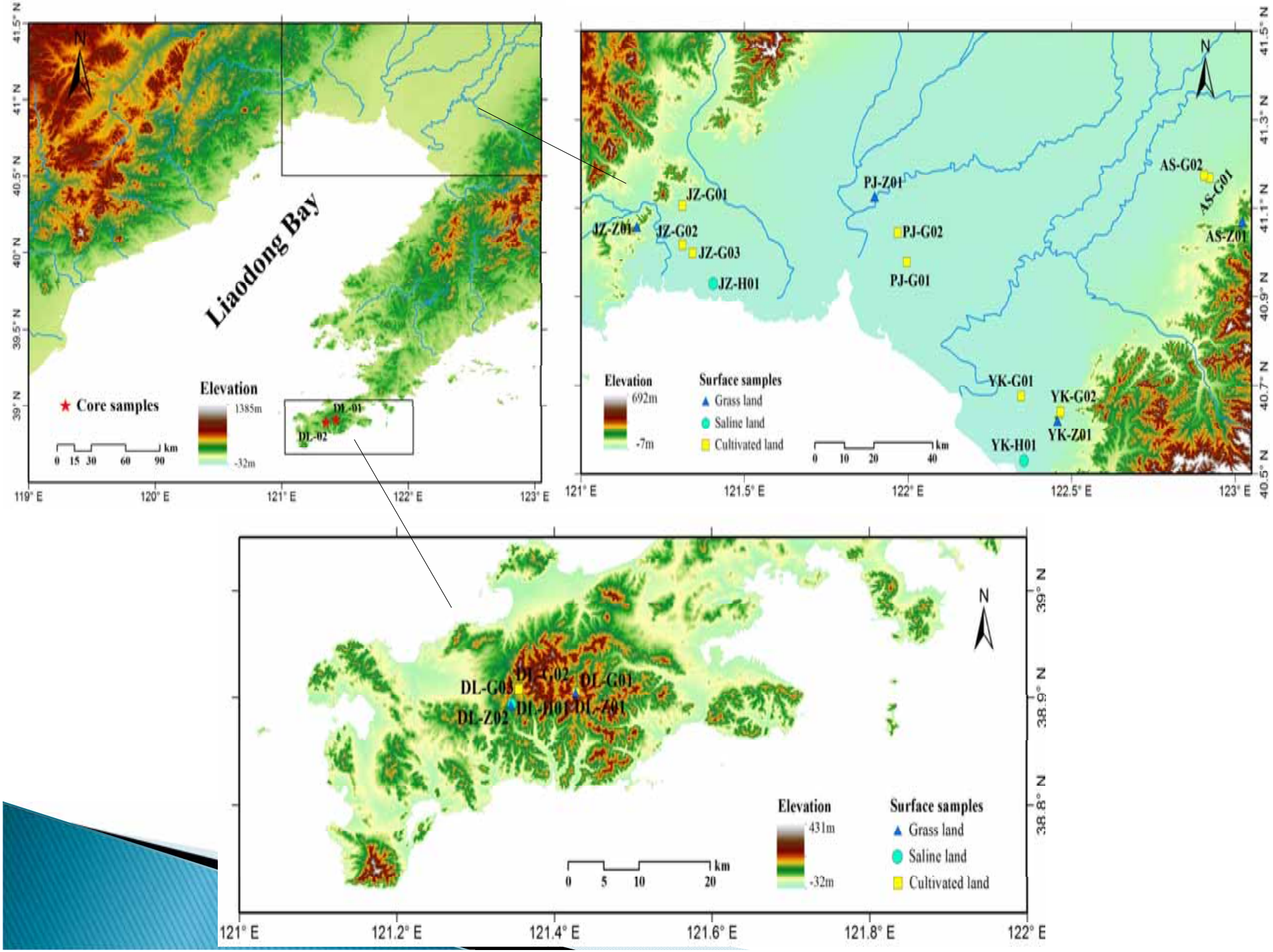


The application of ^{137}Cs for soil erosion study will be difficult in future

----find a substitute

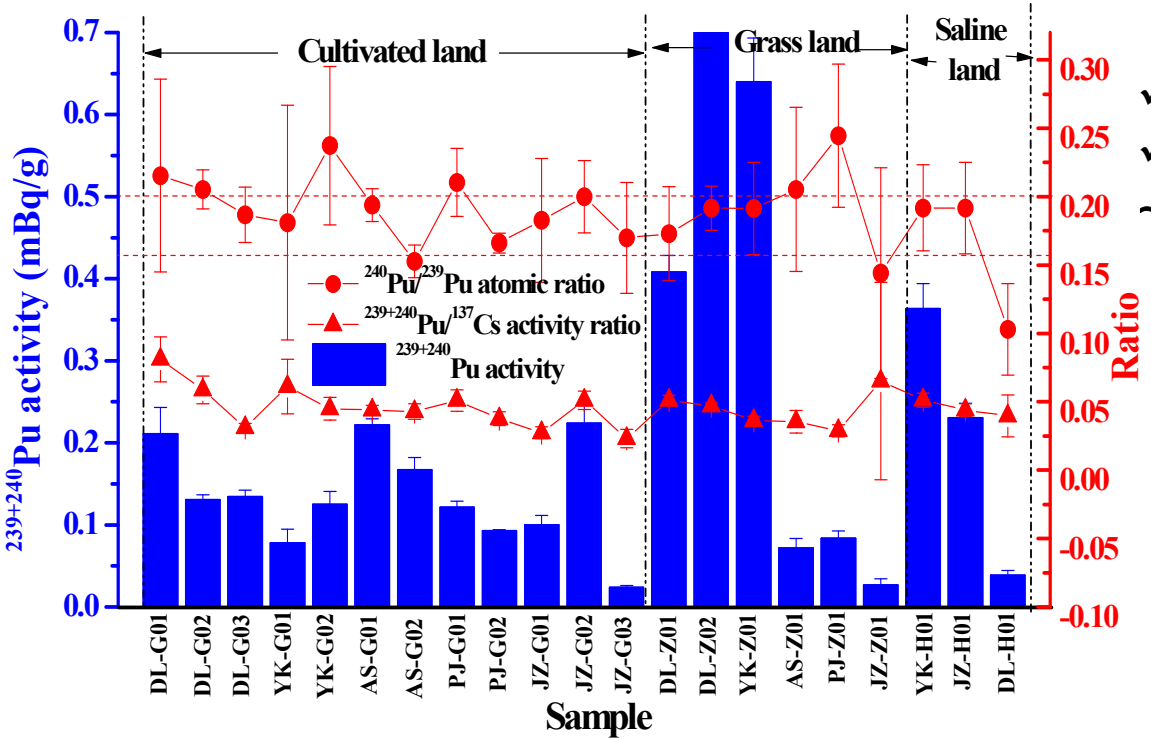
◆Pu isotopes (^{239}Pu and ^{240}Pu) --- potential substitutes of ^{137}Cs for tracing soil erosion

- Same dominating source of global fallout worldwide as ^{137}Cs
- Much longer half-lives (^{239}Pu and ^{240}Pu) than ^{137}Cs
- High particle affinity and low mobility in soil
- More sensitive detection supported by measurement techniques of mass spectrometry


Liaodong Bay
Core samples
Elevation
1385m
-32m
DL-01
DL-02
km
0 15 30 60 90
119° E
120° E
121° E
122° E
123° E
39° N
39.5° N
40° N
40.5° N
41° N
41.5° N
Surface samples
Grass land
Saline land
Cultivated land
692m
-7m
JZ-G01
JZ-Z01
JZ-G02
JZ-G03
JZ-H01
PJ-Z01
PJ-G02
PJ-G01
AS-G02
AS-G01
AS-Z01
YK-G01
YK-G02
YK-Z01
YK-H01
0 10 20 40
121° E
121.5° E
122° E
122.5° E
123° E
40.5° N
40.7° N
40.9° N
41.1° N
41.3° N
41.5° N
DL-G03
DL-Z02
DL-H01
DL-G01
DL-Z01
431m
-32m
0 5 10 20
121° E
121.2° E
121.4° E
121.6° E
121.8° E
122° E
38.8° N
38.9° N
39° N

◆Plutonium in soils collected from northeast China

➢Spatial distribution of plutonium in surface soils



✓ $^{240}Pu/^{239}Pu$ atomic ratio ~0.18

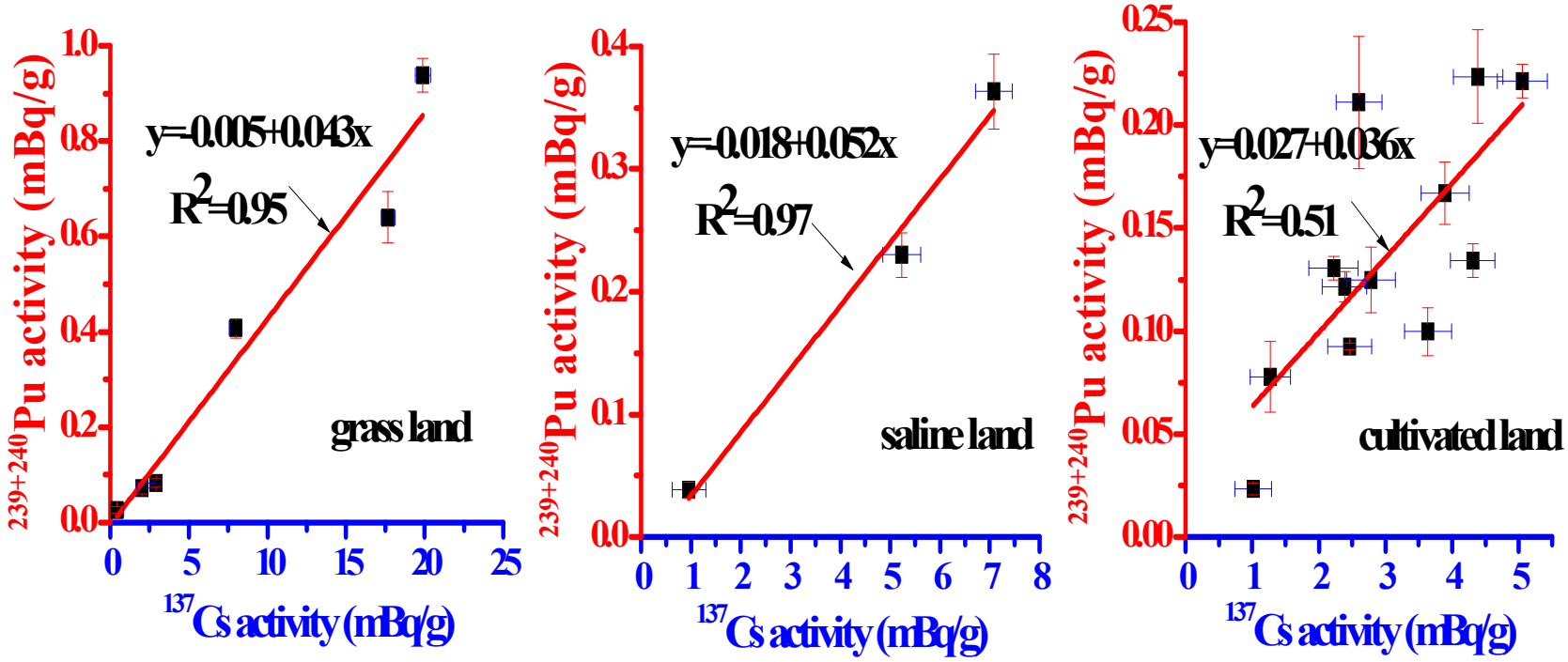
✓ $^{239+240}Pu/^{137}Cs$ activity ratio ~0.045

----major source of Pu in northeast China should be the global fallout Pu from NWT

✓Pu conc. in surface soils varying with land types, Pu conc. in grass land were significantly higher than those in cultivated land

✓ ---- migration behavior of Pu influenced by land use patterns and human activities

➢ Correlation between the concentration of $^{239+240}$Pu and ^{137}Cs in surface soils



✓High correlation between the conc. of Pu and ^{137}Cs were observed in surface soils, especially in grass land and saline land

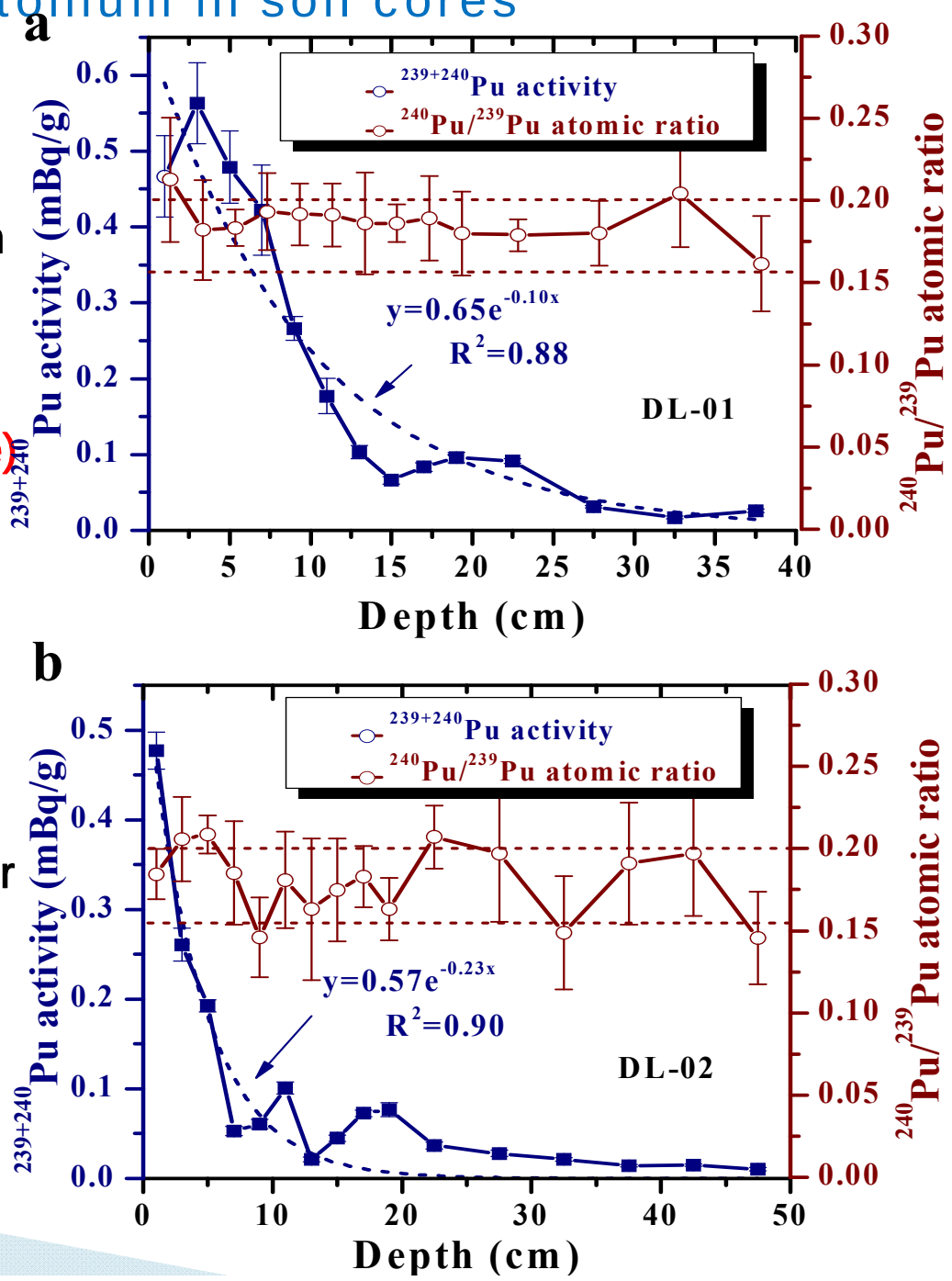
➢ Vertical distribution of plutonium in soil cores

✓ The atomic ratio of $^{240}Pu/^{239}Pu$ in two cores ~0.18

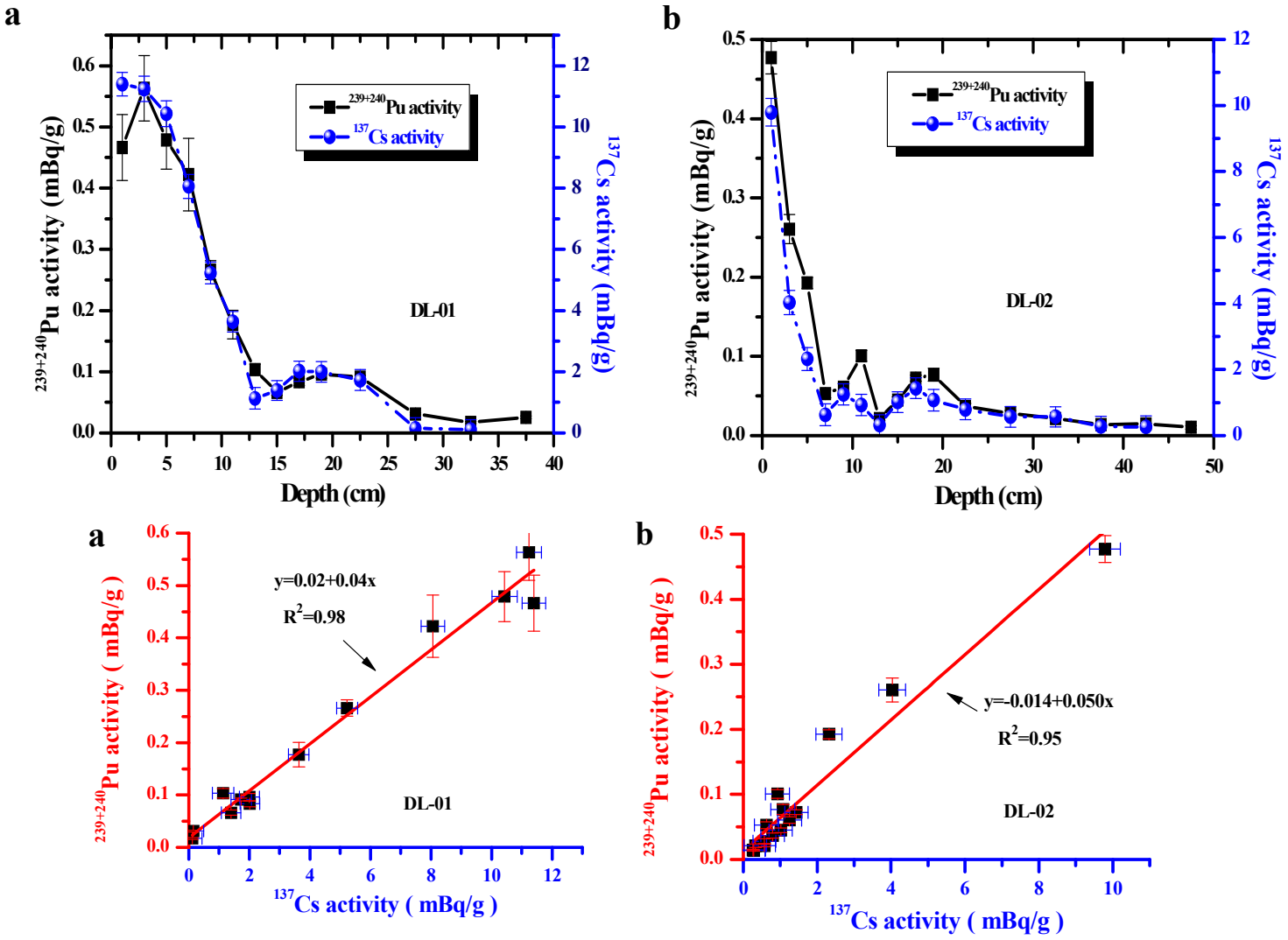
✓The sub-surface maximum of Pu conc. in DL-01 core (reference core)

✓ Pu concentration exponentially decreased with soil depth in both cores

✓ Small peak values of Pu conc. in deep layers---roots, organic matter content



➢ Comparison of the profiles of Pu and ^{137}Cs in each soil core



✓The physical transport of $^{239+240}$Pu and ^{137}Cs in soils should be very similar, they could convey similar information about erosion and redistribution of soils in a small area

◆ The feasibility of using Pu as soil erosion tracer

Table 1 The inventories of Pu and ^{137}Cs in soil cores[a].

Depth (cm)	$^{239+240}Pu$ (Bq/m^2)	$^{239+240}Pu$ inventory distribution (%)	^{137}Cs[b] (Bq/m^2)	^{137}Cs inventory distribution (%)
DL-01				
(reference core)				
0-6	41.8 ± 2.5	48	916 ± 19	54
6-20	33.6 ± 1.9	39	650 ± 25	38
> 20	11.5 ± 0.3	13	138 ± 40	8
Total	86.9 ± 3.1		1704 ± 40	
DL-02				
(studied core)				
0-6	24.5 ± 0.6	56	426 ± 17	56
6-20	11.3 ± 0.4	26	175 ± 22	23
> 20	8.2 ± 0.4	18	163 ± 46	21
Total	44.1 ± 0.9 (51%)[c]		764 ± 47 (45%)[c]	

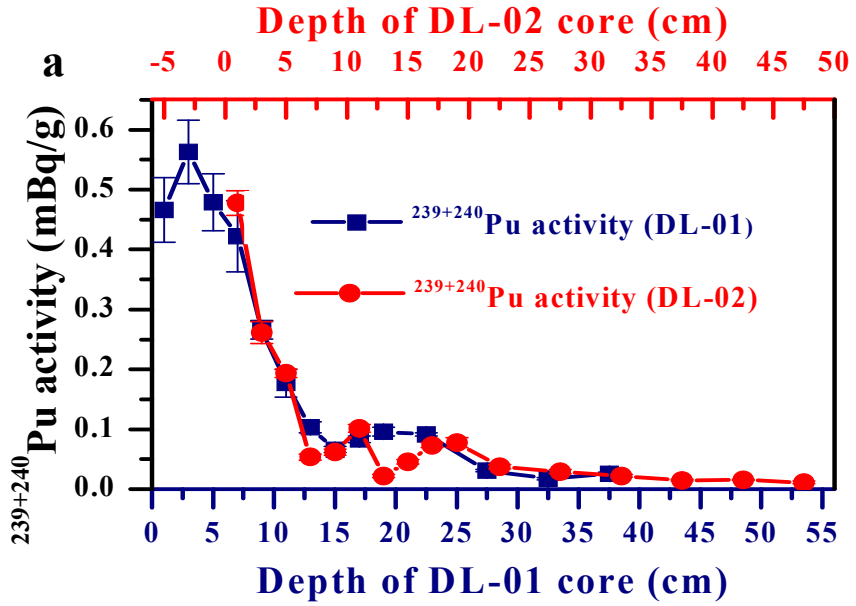
[a] All given uncertainties are one standard deviation.
[b] ^{137}Cs activities were decay corrected to 1st Sept. 2009.
[c] Numbers in parentheses indicate percentages relative to the inventory of the reference core DL-01.

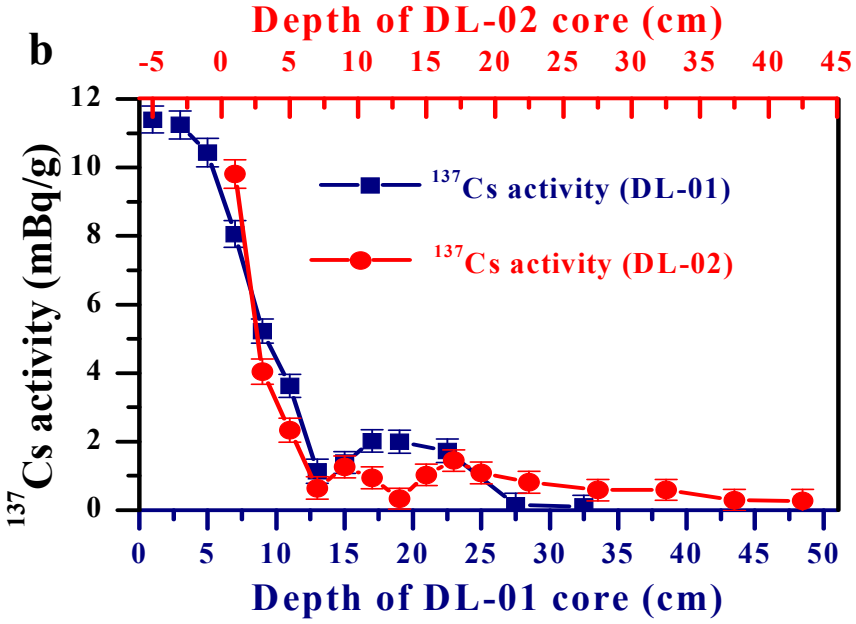
◆ The feasibility of using Pu as soil erosion tracer

✓Comparing the Pu profiles between the two soil cores, deducing that the top ~6 cm soil in the site of DL-02 core might be eroded;

✓Similar conclusion could also be deduced based on the ^{137}Cs profiles

---- Pu could be an ideal substitute of relative short-lived fallout ^{137}Cs for tracing soil erosion and redistribution in the future.





◆Future work

✓ To estimate the intensity of the erosion in a specific site of the area, more comprehensive work involving analsis of Pu profiles in a series of soil cores and modeling of downwards migration of Pu has to be carried out.

Thank you for your attention!