Learning from subsurface migration profiles of an artificial radionuclide during a volatile migration period

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Study Framework

Questions

- Environmental radioactivity in a dynamic mobilization period vs. stabilized state

Problem

- A limited consideration on local topography

Approach

- Radionuclide movements ..
- Over a short time following anthropogenic fallout..
- By the influence of local topography ..
- Implication to environmental radioactivity assessment and modeling

Radioactivity Source

- Anthropogenic fallout (2011)

Measured Radioactivity

- Soils (30 cm depth)
- Air dose rates

Target Radionuclides

- Radiocesium (soils)
- γ radiation (air)

Driver

- Forest topography

Status

- Dynamic (less than 10 years after fallout)

Topography

- Undulating (forest)

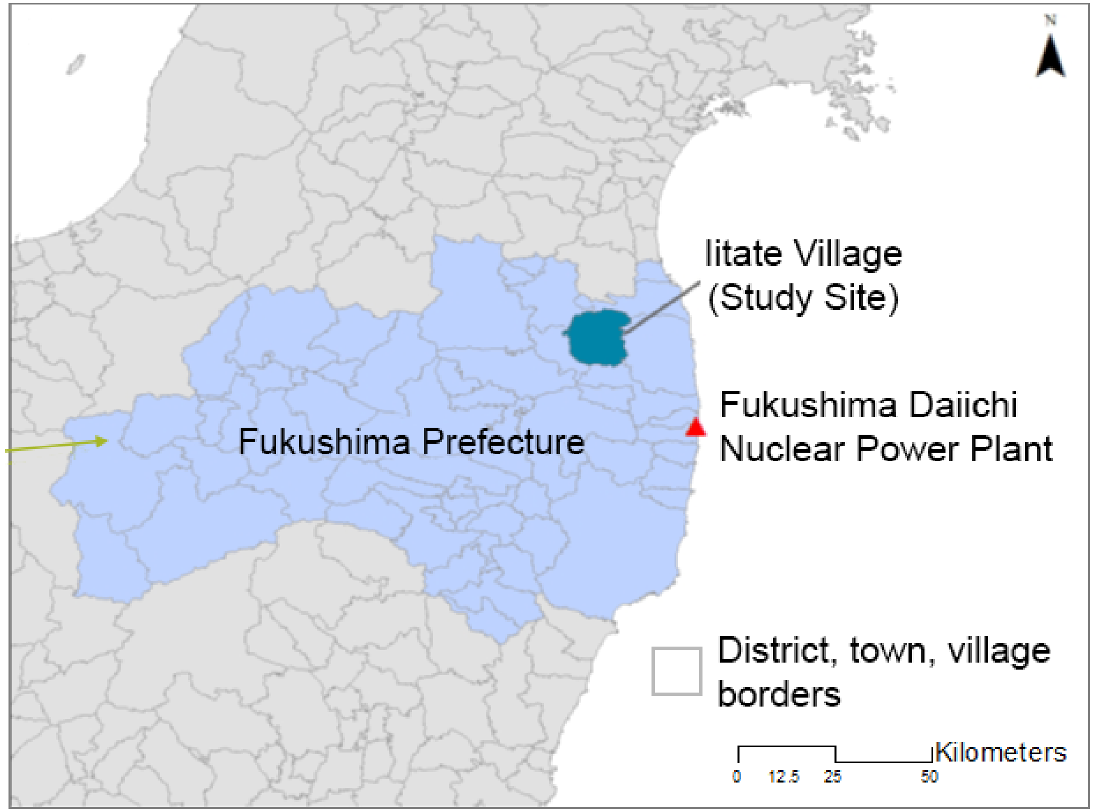
Climate

- Humid, 1000 mm rain $year^{-1}$

Location

- Fukushima, Japan (35 km northwest of FDNPP)

Study Site, Data, Method



Soils (2016-2018) – 64 samples; 30 cm depth

Topographic parameters:

elevation, slope, upslope distance, TWI, plan curvature

Measurement: Isotope analysis

Analytical method:

GAM (Generalized Additive Models)

Air Dose Rates (2018-2019) – 3 survey dates

Topographic parameters:

elevation, slope, upslope distance, aspect, plan curvature

Measurement: Hand-held, backpack-type device

Analytical method:

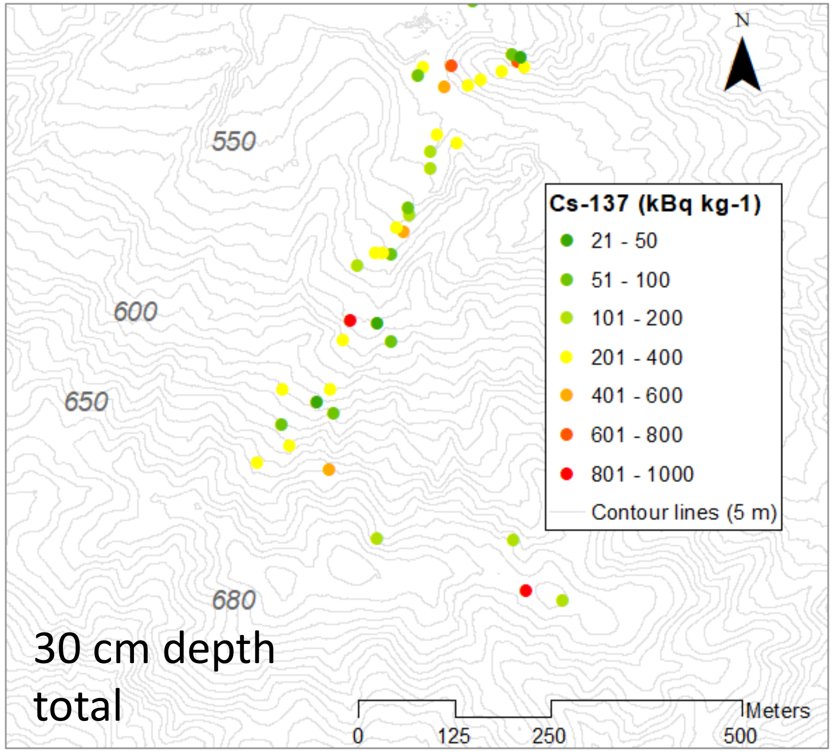
MARS (Multivariate Adaptive Regression Splines)

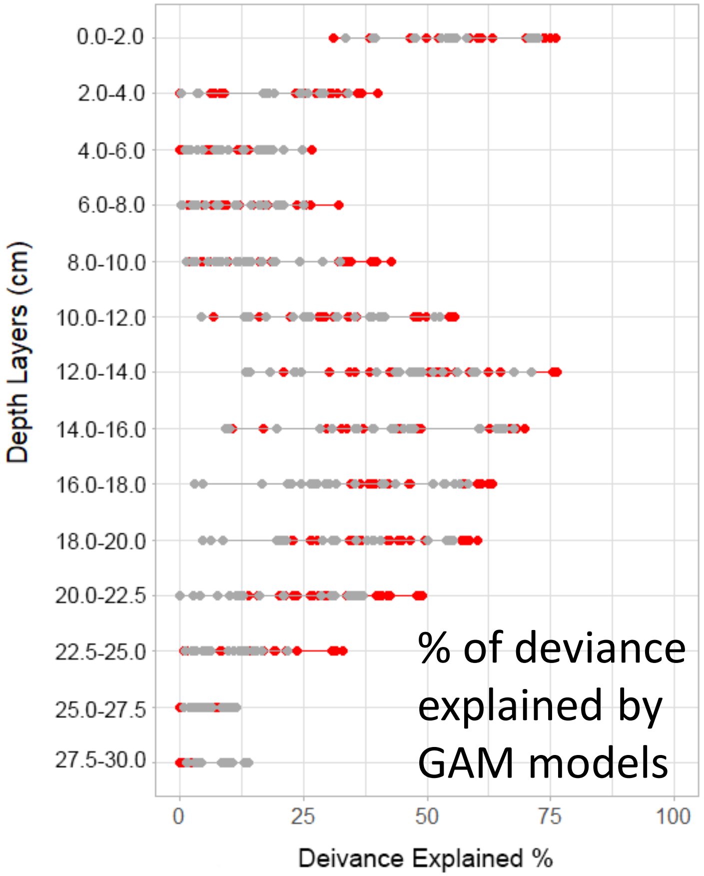
Results: Soils

Soils

1) Spatially heterogeneous: a few accumulation points
2) Best variable combo (≤ 3):

   Elevation, slope, upslope distance
3) Best deviance explained %: 46.70%
4) Best explanation depths: 12-14 cm



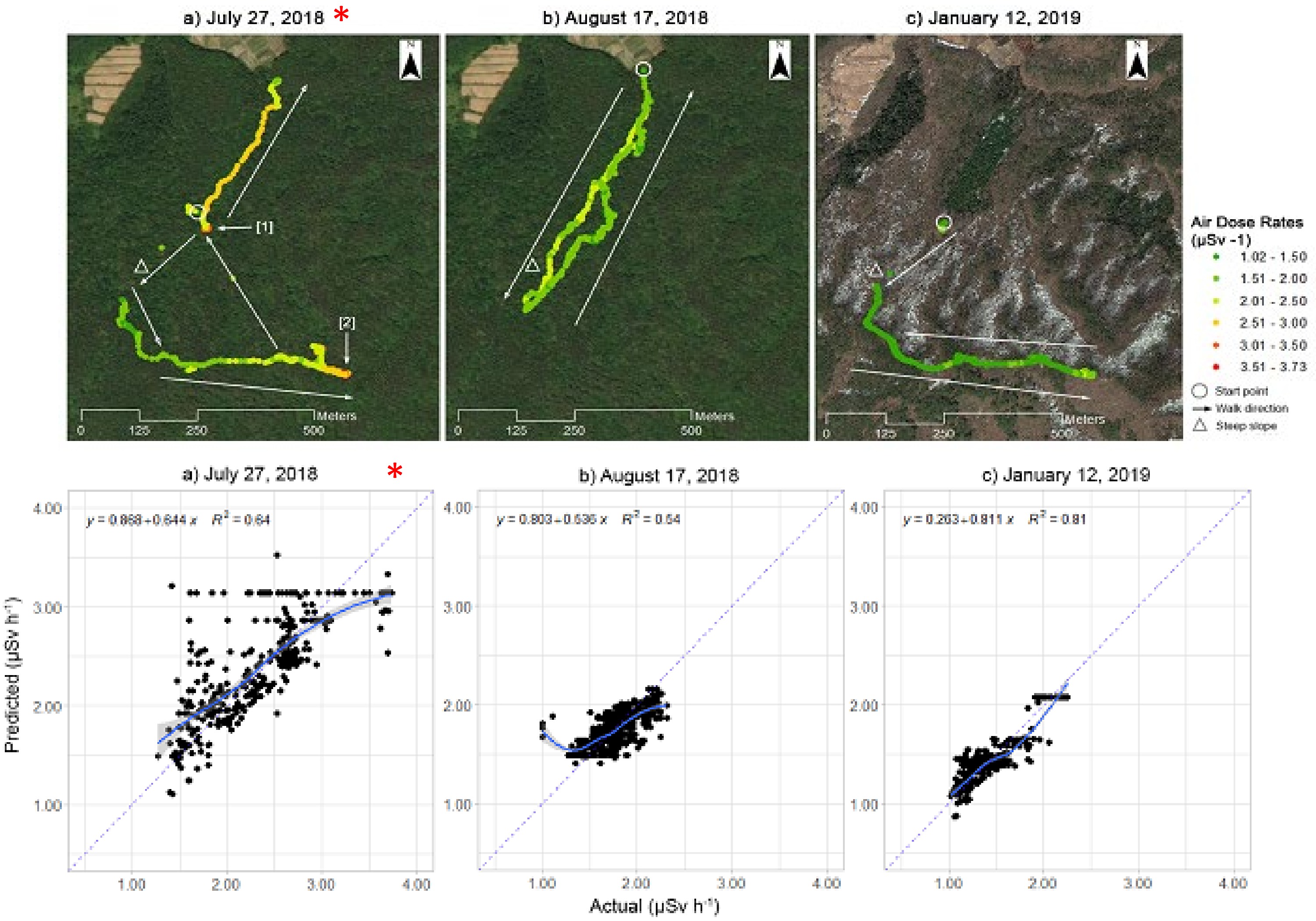


% of deviance explained by GAM models

Results: Air Dose Rates

Air Dose Rates (µSv h^{-1})

1) Heterogeneous activity levels and spatial distributions by date
2) Influential topographic parameter ranking varied by date
3) However, when topographic parameters are combined in models, prediction accuracy R^2 - 0.54 (July)*, 0.64 (Aug), 0.81 (Jan)



* Perceived as most accurate with dry ground.

Discussion, Implications, New Questions

Discussion

- Conventional governing factors (elevation, slope) might not be sufficient to explain topographic effects ~ scale?
- Remaining ≤ 50%: precipitation, soil characteristics, vegetation, animals, winds, redepositions, etc.
- Best predicted depth in soils: the mid-depths (surface topographic effects were carried down)

Implications to environmental radioactivity modeling

- What are we measuring? ~ depth and timing decision
- Lost information ~ can we reverse model the effects after 10, 100 years?
- Influence on ground-to-air attenuations

New questions

- Why 50%, not 30% or 90%?
- How far (deep) will the topographic influences be carried over at what rate?

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