

# **Water resource management in tectonically active volcanic regions: towards an in-depth understanding of Mt. Fuji's hydrogeology**

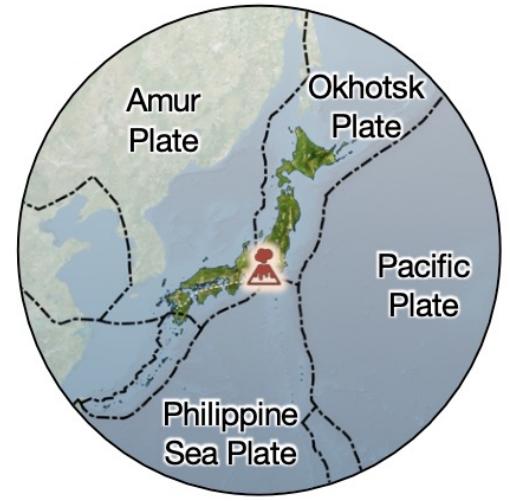
**Musy S., Currle F., Nakajima T., Tomonaga Y., Sano Y., Schilling O.S.**

23.11.2023



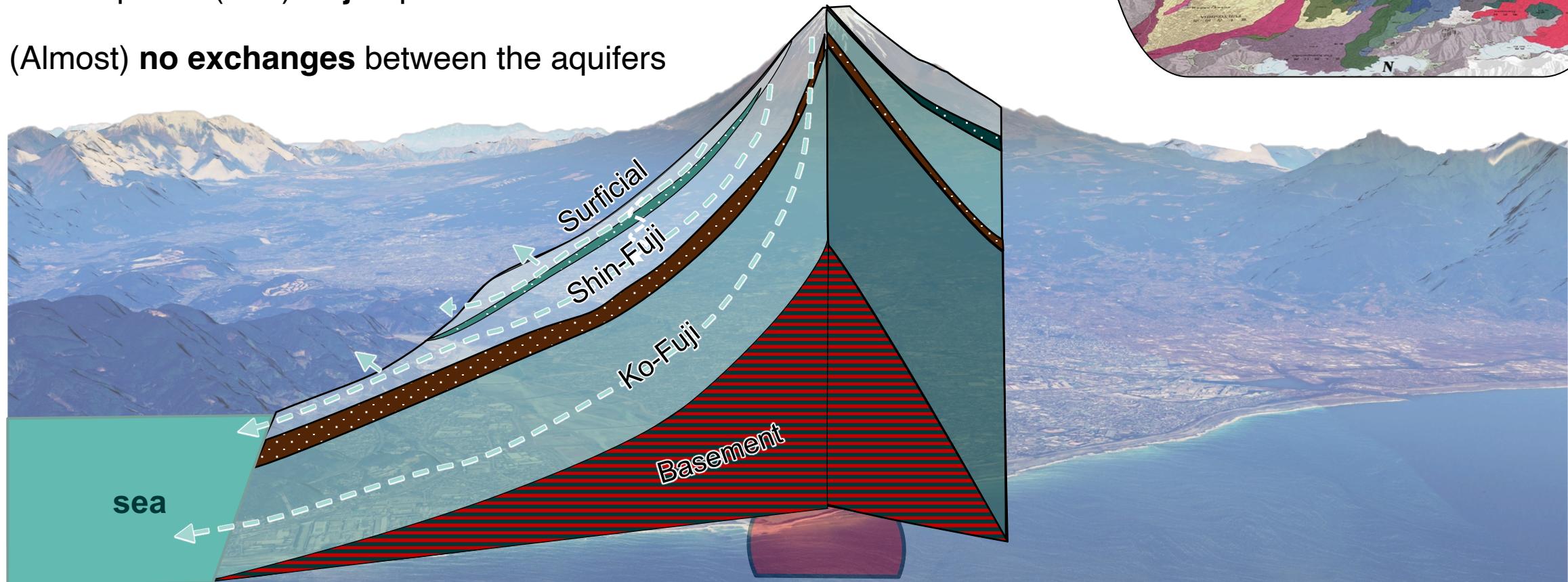
# Introduction : Fuji-San (3776 m)

- Tectonically active, intensely used watershed
- Steady **decline of water quality & quantity** in the last two decades
- Despite a century of studying Mt. Fuji<sup>1,2</sup>, many unsolved questions exist about the **origin of its waters**



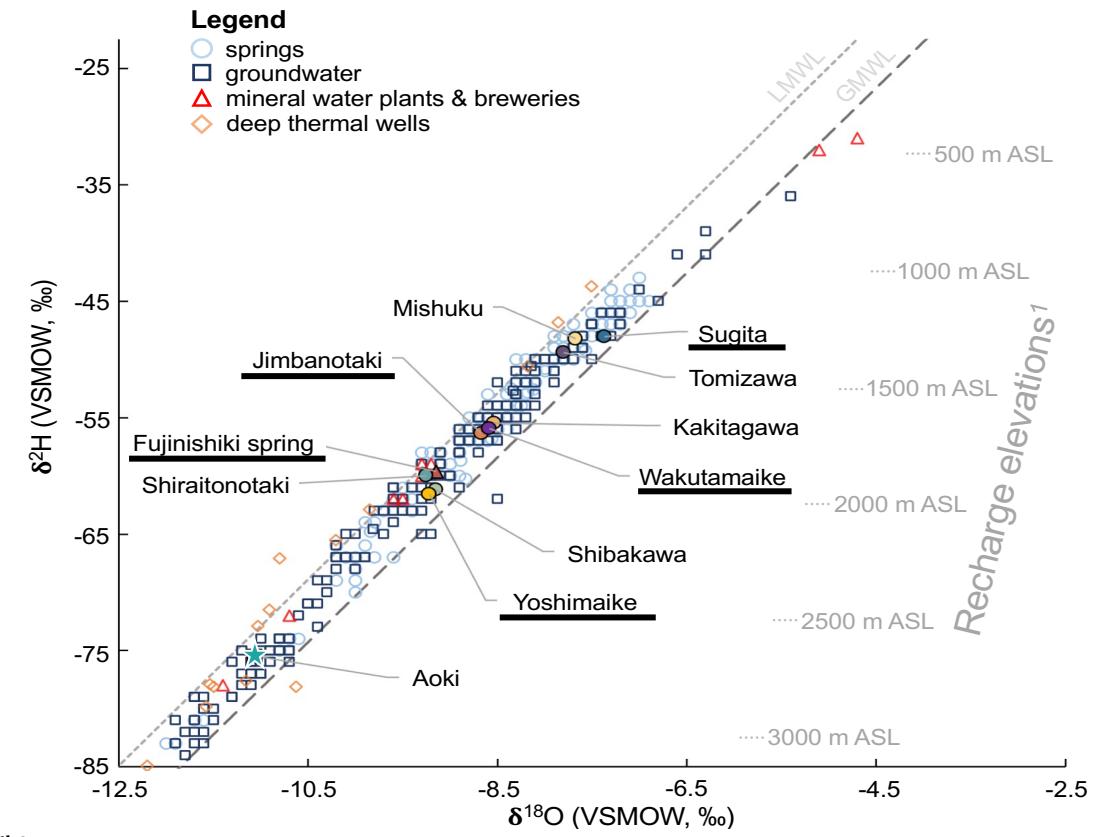
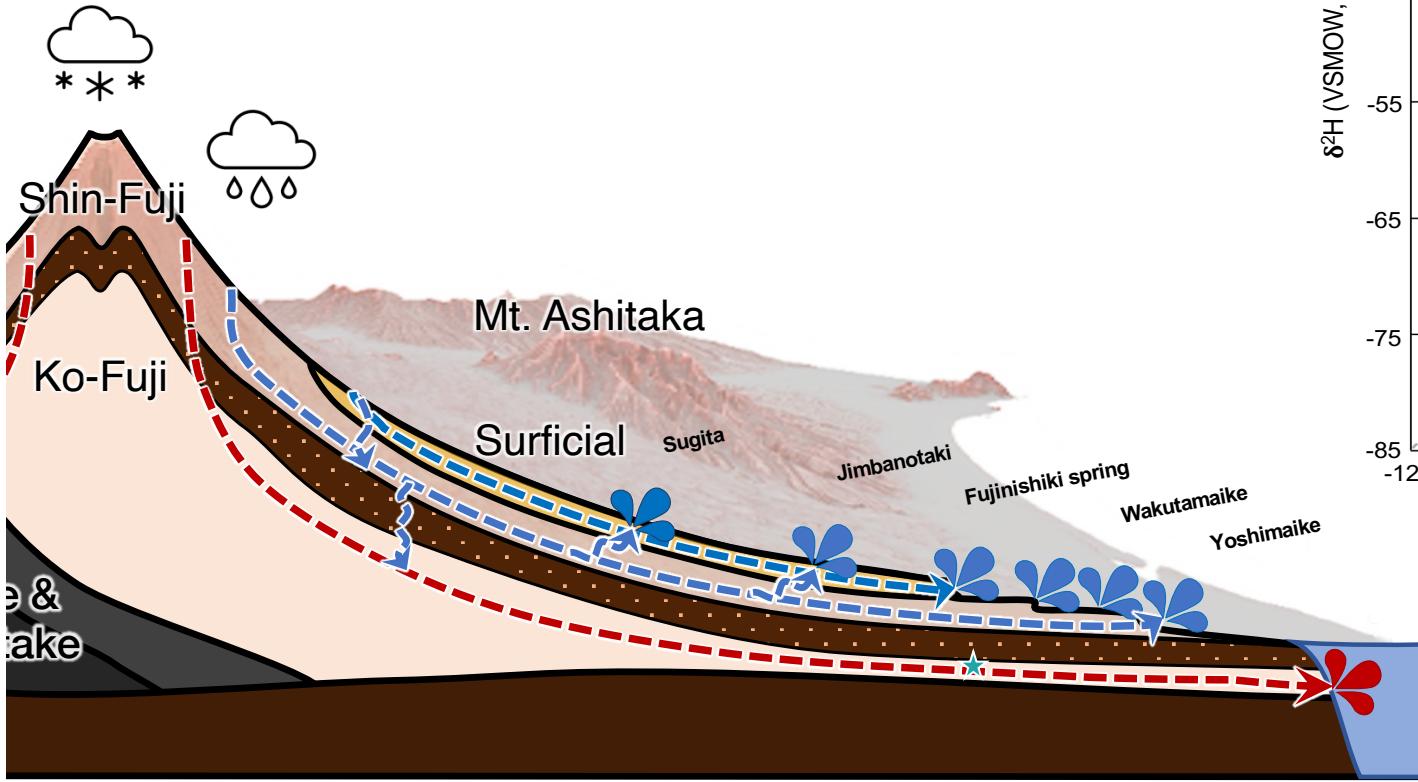
# Hydrogeology of Mt. Fuji : classic conceptual model

- 3 aquifers, separated by 'impermeable' layers:
  - Top: **Superficial** aquifer
  - Middle: Young ('**Shin**')-Fuji aquifer
  - Deep: Old ('**Ko**')-Fuji aquifer
- (Almost) **no exchanges** between the aquifers



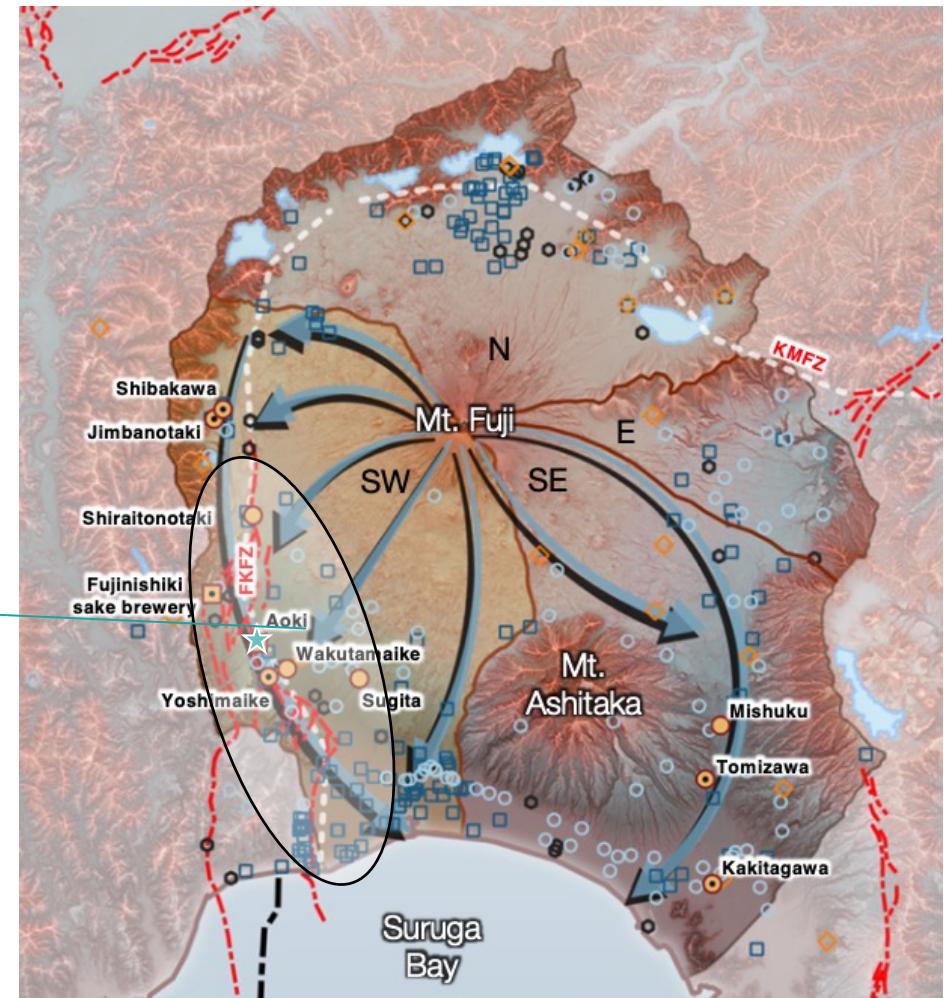
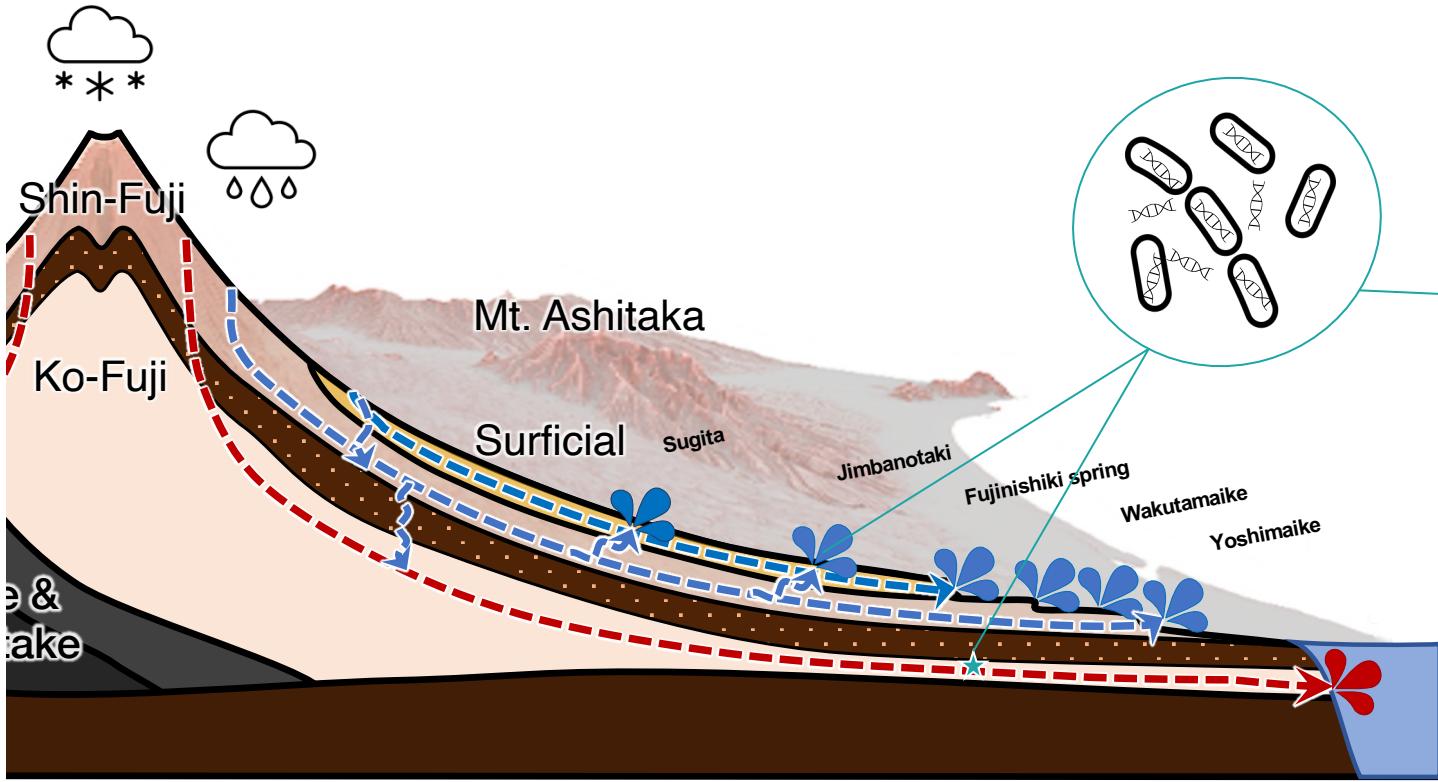
# Hydrogeology of Mt. Fuji : classic conceptual model

- Classic **stable water isotope & major ion observations** support the topographic – unmixed model of the system



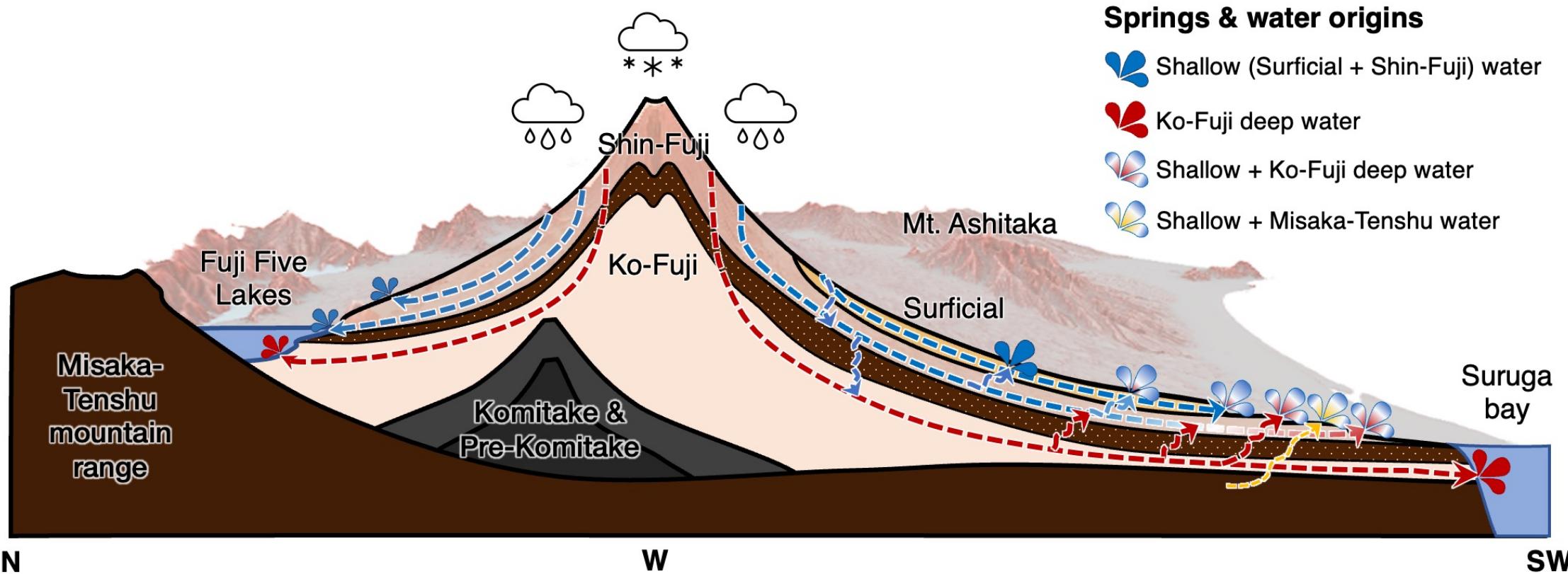
# Hydrogeology of Mt. Fuji : classic conceptual model

- Classic **stable water isotope & major ion observations** support the topographic – unmixed model of the system
- **Thermophile Archae** observed in several cold-water springs situated along the Fujikawa-kako Fault Zone (FKFZ)<sup>2</sup>



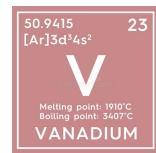
# Revisiting Mt. Fuji's groundwater origin

- Study by Schilling et al. (2023, Nat. Water)
- Important and previously underestimated recharge pathway for springs and shallow groundwater along the tectonic faults via the deep Ko-Fuji aquifer



# Revisiting Mt. Fuji's groundwater origin

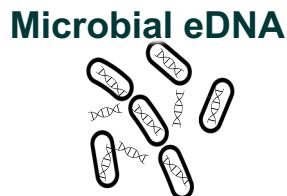
- Study by **Schilling et al. (2023, Nat. Water)**
- Important and previously underestimated **recharge pathway for springs and shallow groundwater along the tectonic faults via the deep Ko-Fuji aquifer**
- Combination of **three unconventional tracers**:



- Concentrations up to 150 µg/L
- Residence time proxy
- **BUT: unclear if deep or just slow groundwater flow**



- Concentrations up to  $2.2 \times 10^{-5} \text{ cm}^3 \text{ g}_w^{-1}$  ( $\approx 10^3 \times \text{A.S.W}$ )
- ${}^3\text{He}/{}^4\text{He}$  signatures from mantle origin
- **BUT: unclear if water or gas is upwelling**

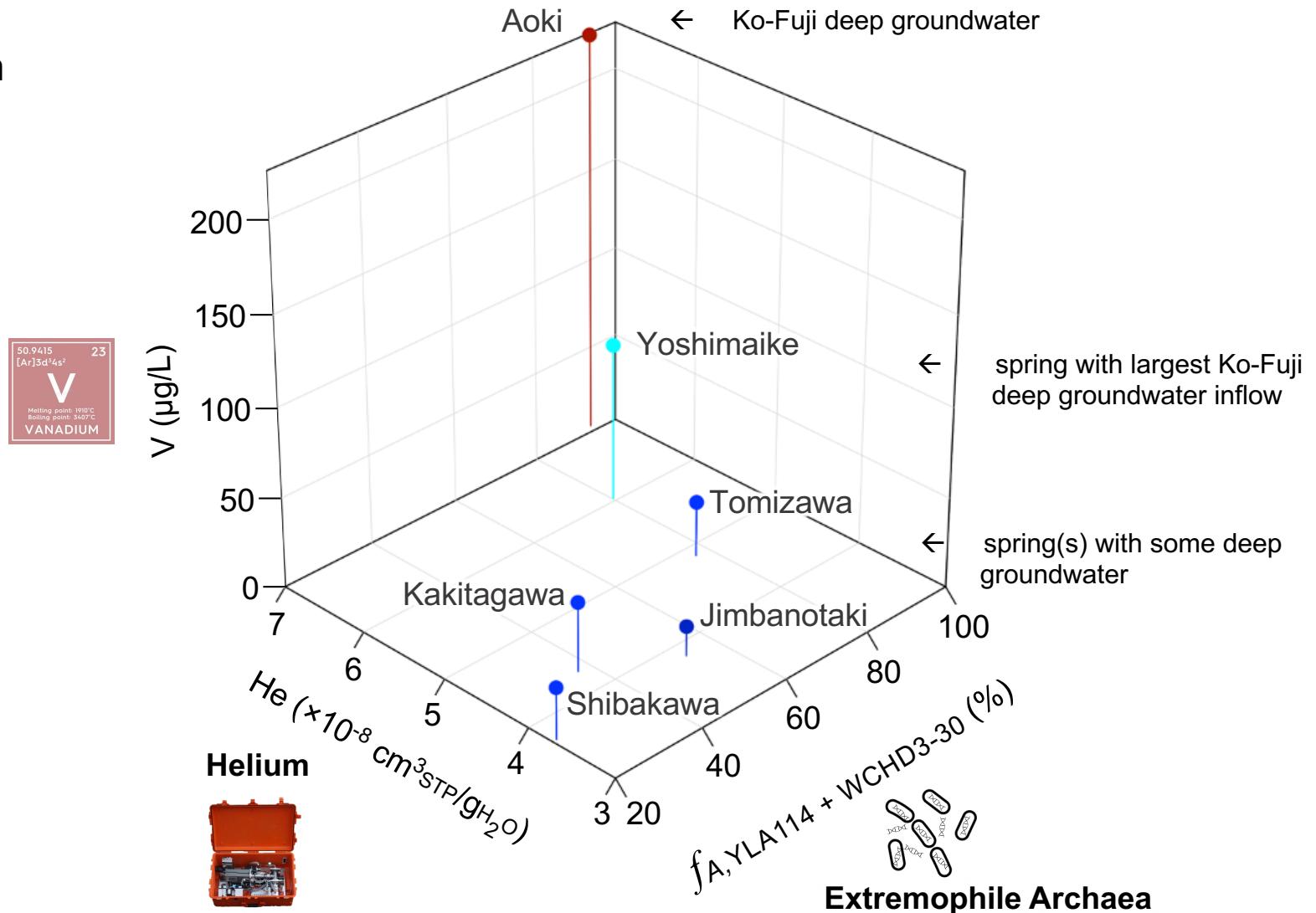


- Large proportion of extremophiles in springs and groundwater
- **BUT: not enough evidence for groundwater flow**

# Revisiting Mt. Fuji's groundwater origin

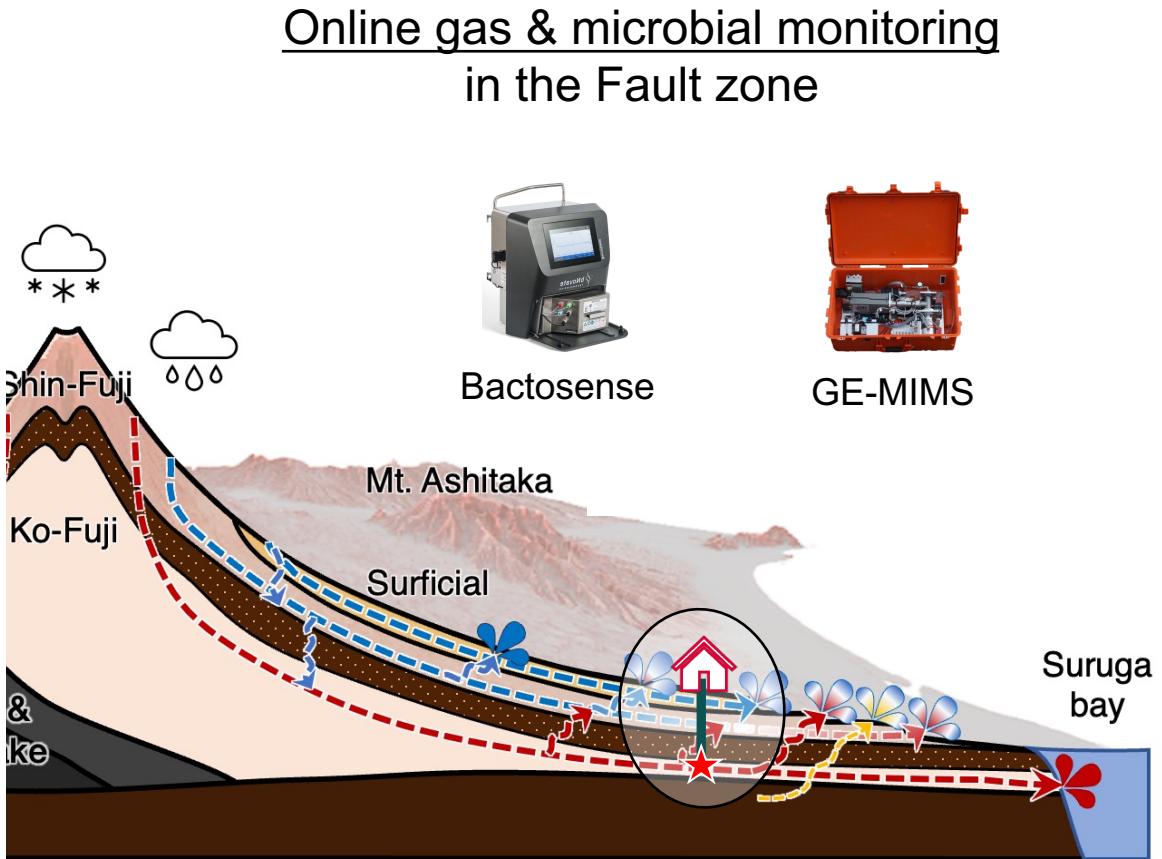
- Near-linear triple-tracer correlation

→ Striking evidence of  
deep groundwater upwelling



# Towards an in-depth understanding

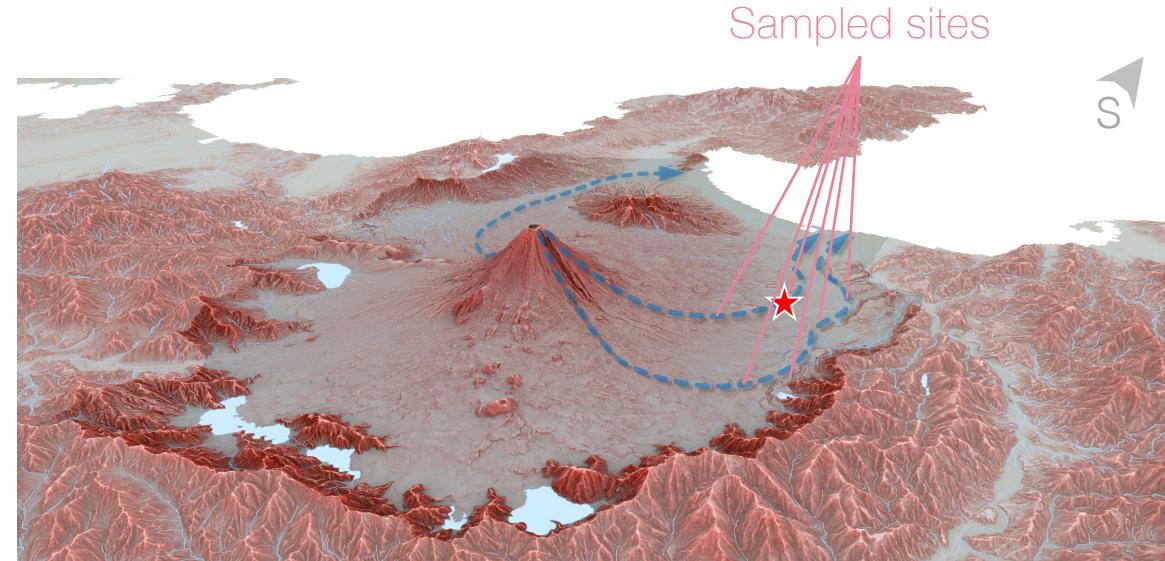
- **Temporal and spatial dynamics** of the upwelling
- **Tectonic and seismic activities**  $\longleftrightarrow$  Groundwater



## Multi-tracer sampling campaign

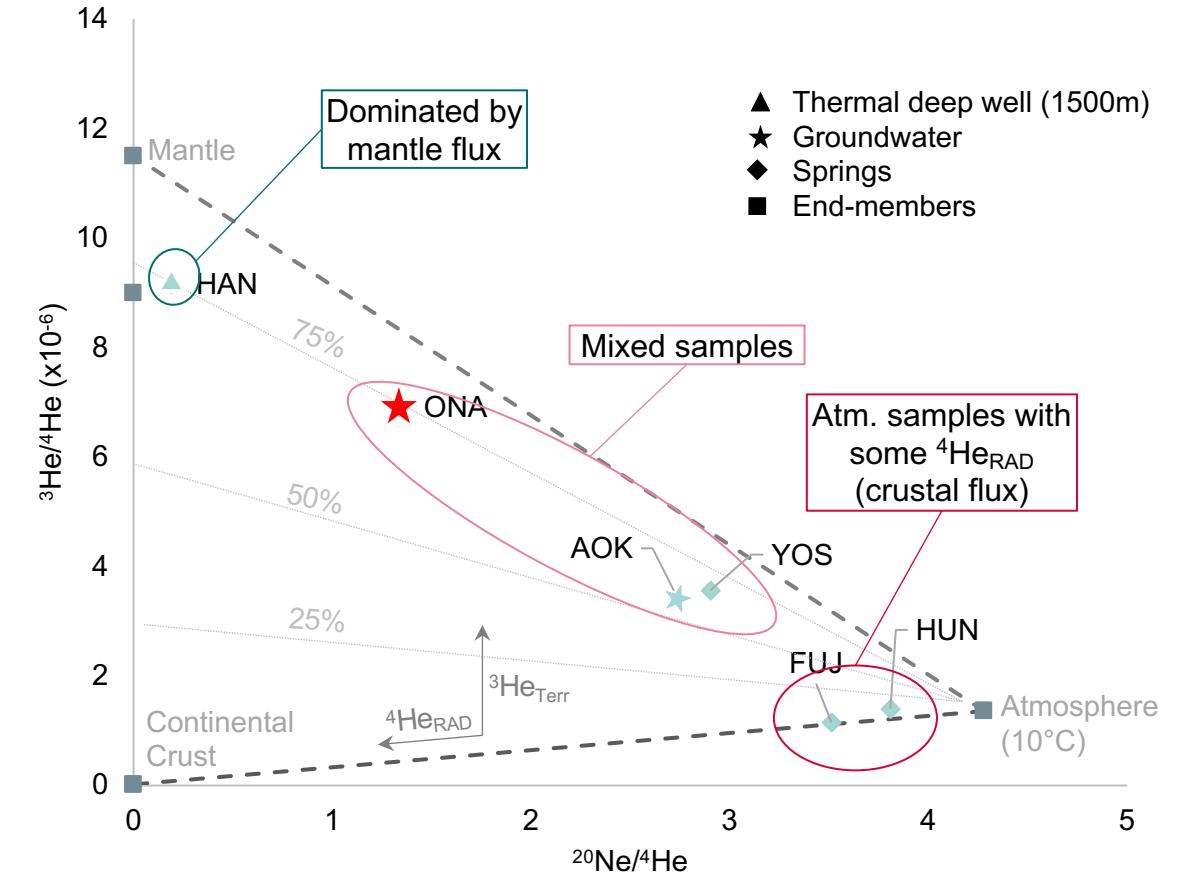
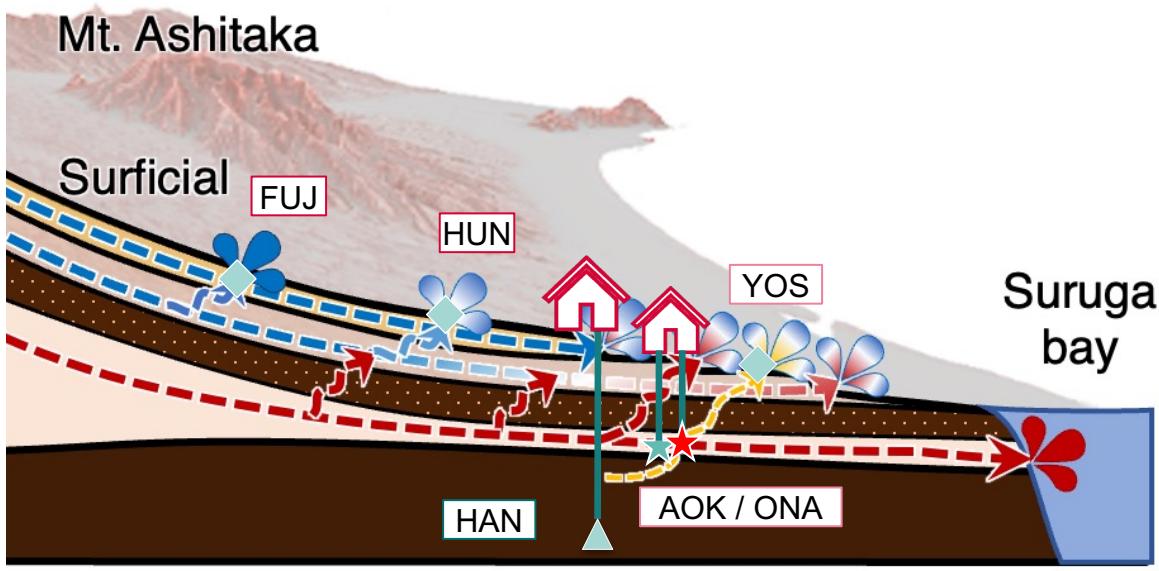


- ${}^4\text{He}/{}^3\text{He}$
- ${}^{20}\text{Ne}$ ,  ${}^{40}\text{Ar}$ ,  ${}^{84}\text{Kr}$
- $\delta^{18}\text{O}$ ,  $\delta^2\text{H}$
- Major ions
- Trace elements



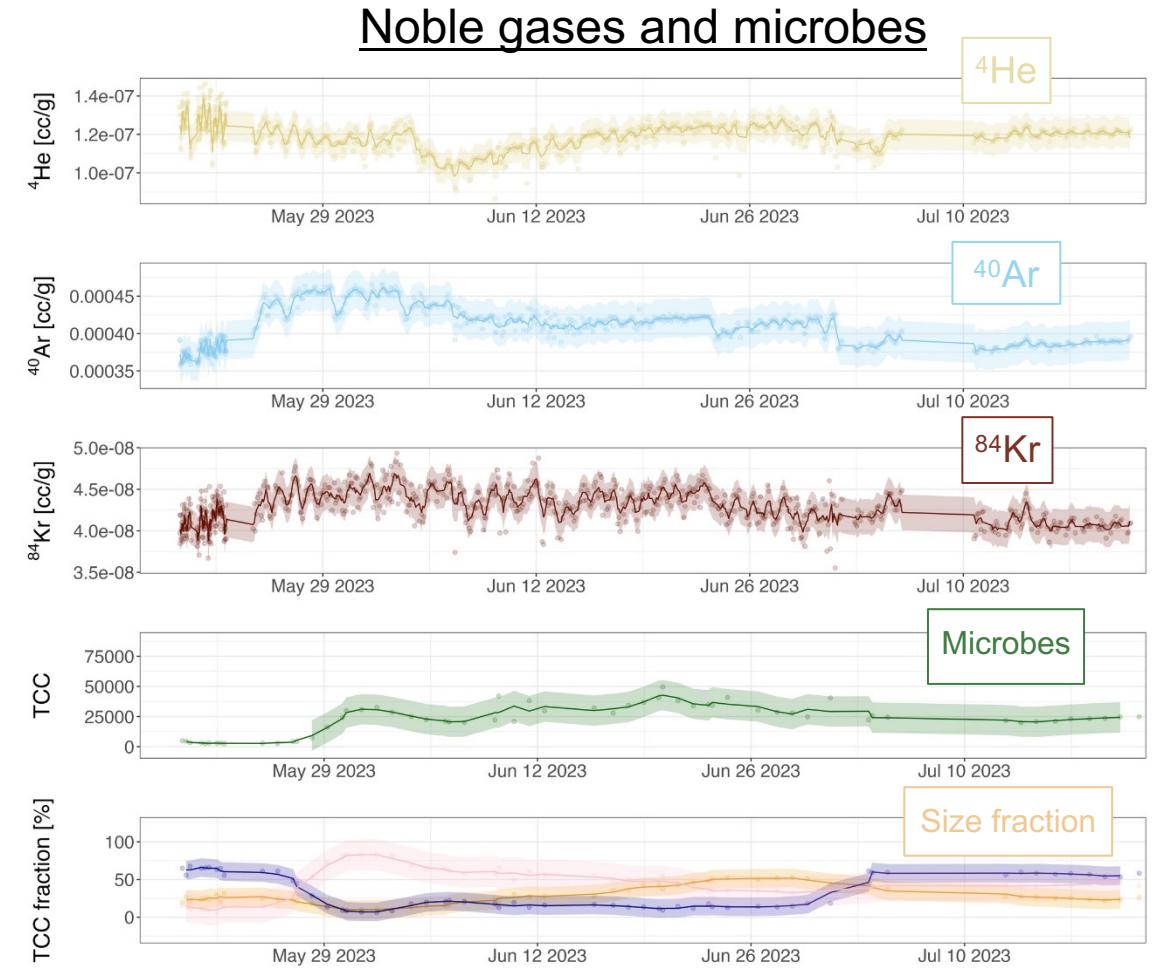
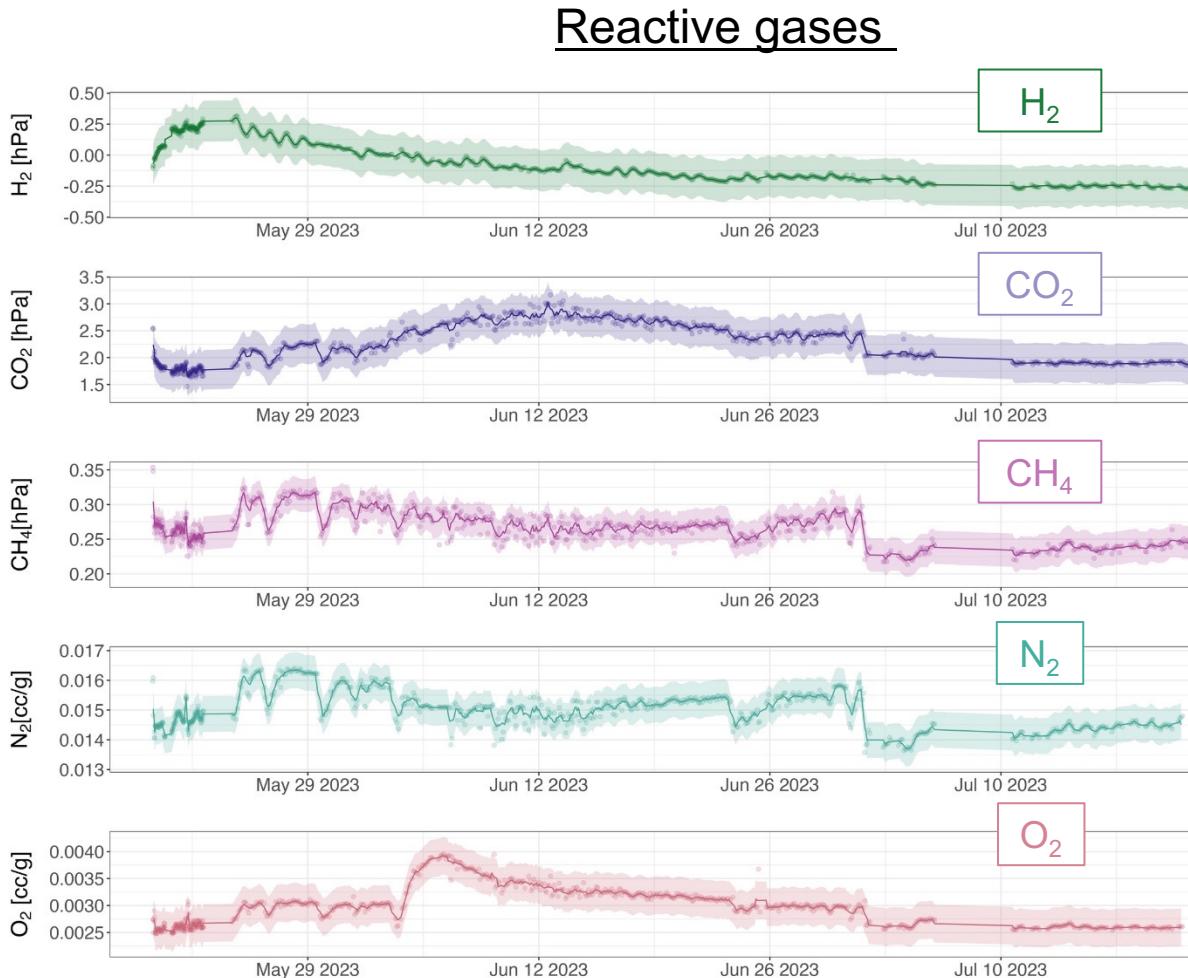
# Preliminary results: helium isotopes

- ${}^3\text{He}/{}^4\text{He}$  isotopes inform about the **origin of (helium) fluxes**
- The **SW foot** of Mt. Fuji is a **mixing zone** for deep old and shallow atmospheric groundwaters

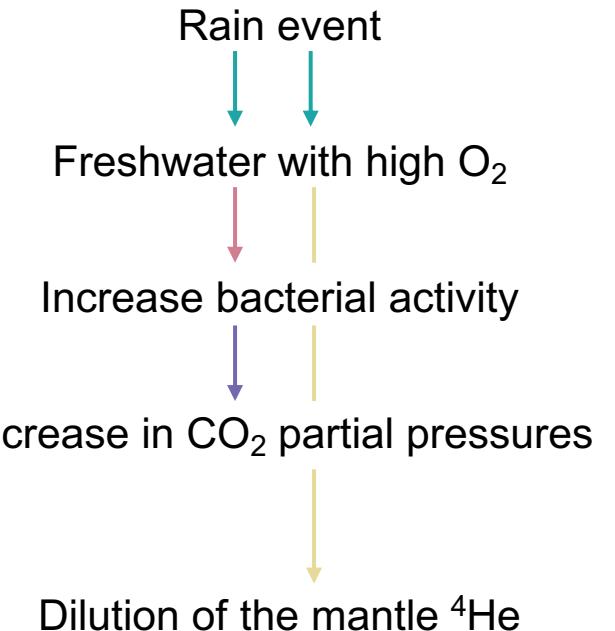
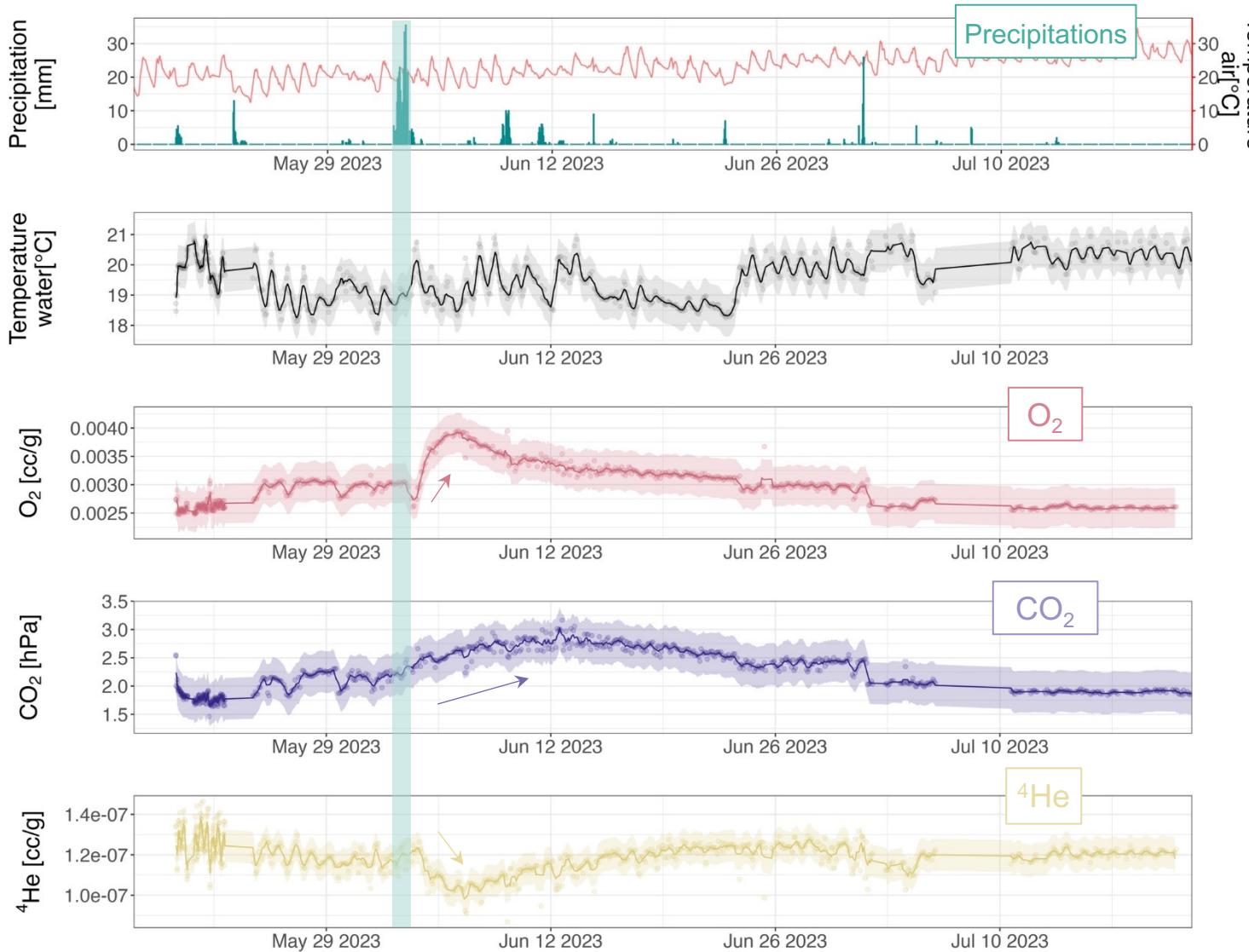


# Preliminary results: online monitoring

- Continuous measurements at 100m in the fault zone (Onakazato well)

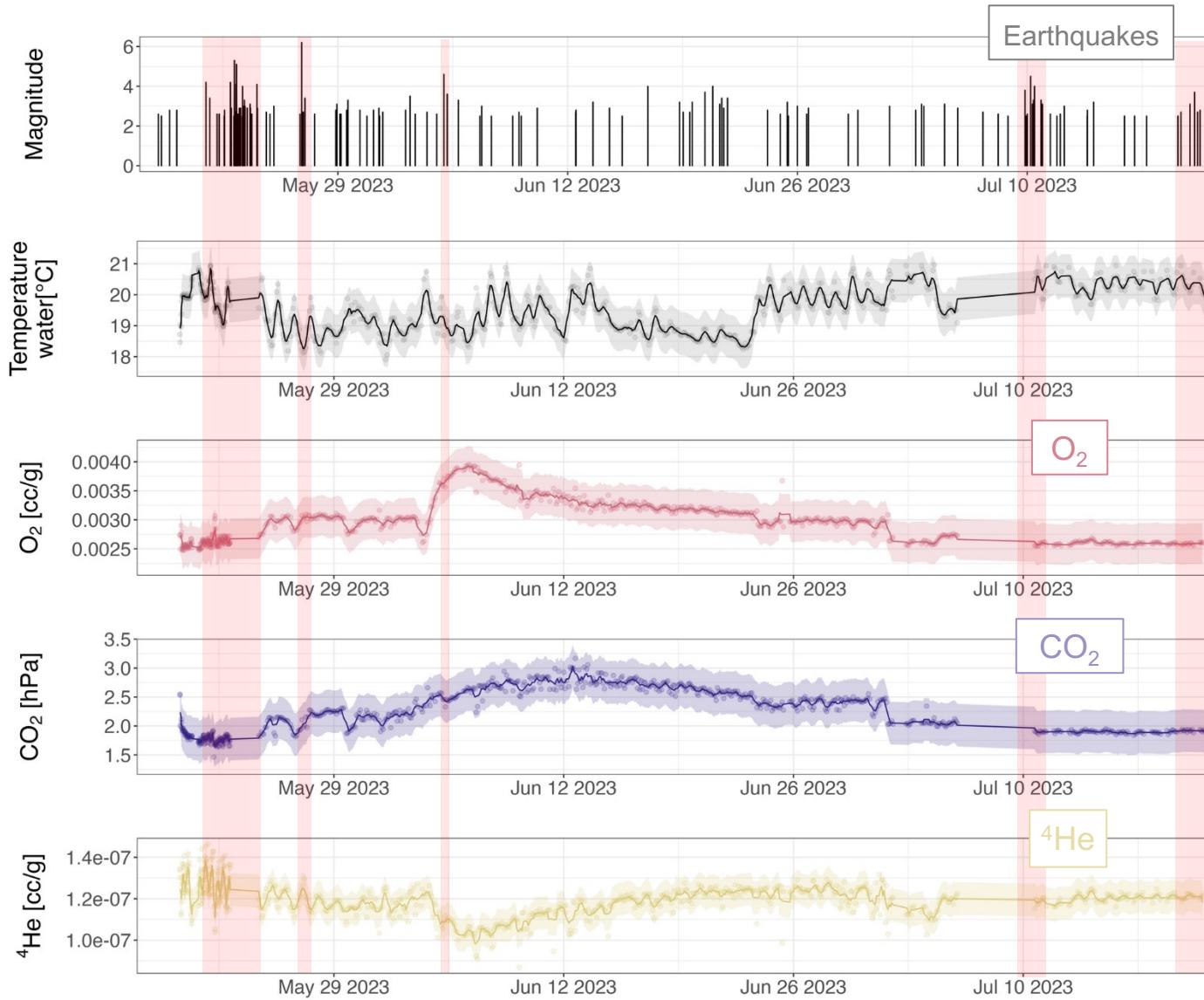


# Preliminary results: online monitoring



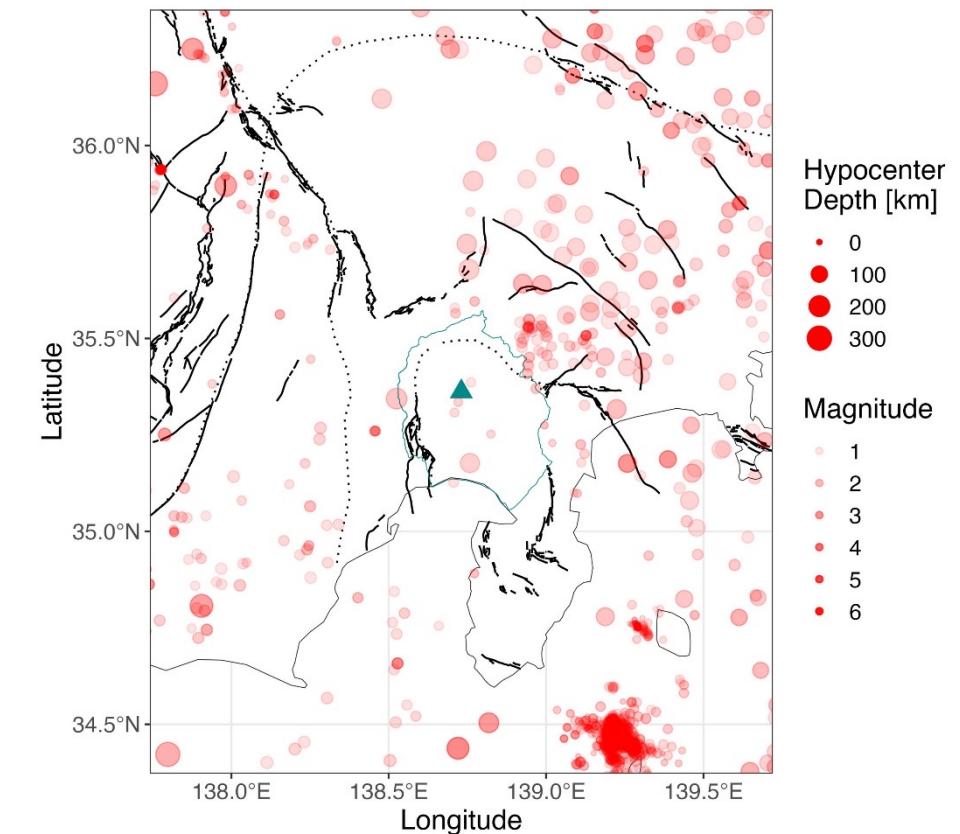
→ Changes in the **mixing ratios** between the deep and the shallow water components

# Preliminary results: online monitoring



Influence of the **seismicity** on the dissolved gas concentrations:

- Not clear yet
- Noisy signal



# Take home



An upwelling of deep (old) groundwater could be identified in Fuji's aquifer thanks to unconventional tracers<sup>1</sup>



Online monitoring of the groundwater in the fault zone for dissolved gases (GE-MIMS) and microbes (Bactosense)



Observation of the response of the system to:

- Hydraulic forcings
- Seismicity



Data with high temporal resolution are crucial in dynamic environments

# Outlooks



More data – longer timeserie



Extend the geographical distribution of  ${}^3\text{He}/{}^4\text{He}$  samples



3D-geological model → Integrated surface-subsurface hydrological model (ISSHM)  
→ Climate projections

# Thank you



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