Determine V_{S30} based on empirical equations of the shear-ware velocity with void ratio and effective stress relationships and extrapolation methods for the Taipei Basin

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Date: 2022/10/07

Outline:

1. Introduction
2. Methodology
3. Preliminary results
4. Future work

MOTIVATION AND PURPOSE

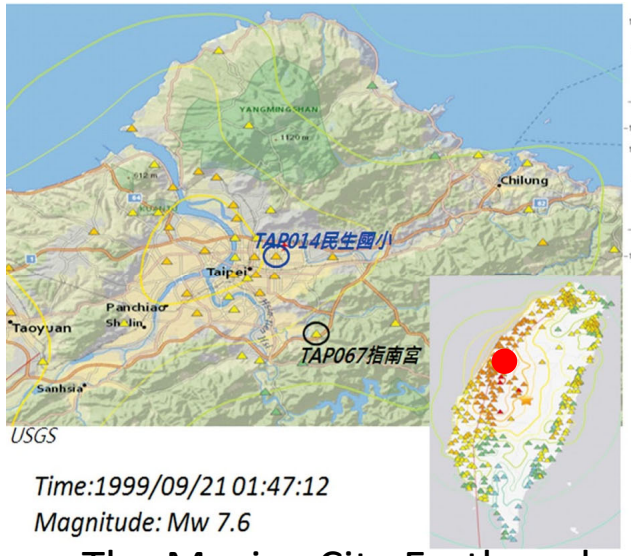
What is the V_{S30} ?

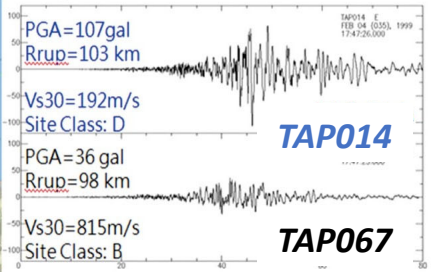
The time-average shear wave velocity (Vs) of upper 30 meters of a soil profile.

Vs30(m/s)	Class	Description
>1500	A	Hard rock
760-1500	B	Rock
360-760	C	Very dense soil/ soft rock
180-360	D	Stiff soil
<180	E	Soft soil

BSSC,2001

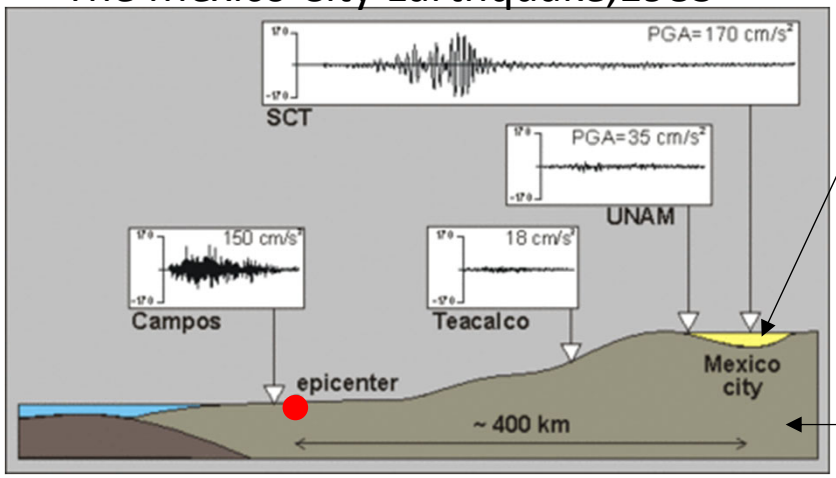
What is seismic site effect?





Source : Chun-Hsiang Kuo(2017) https://quakeledge.blogspot.com/2018/02/blog-post76.html

The Mexico City Earthquake,1985



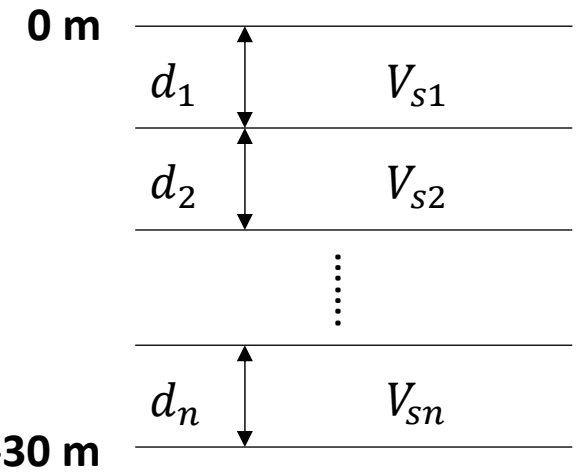
The Site classification is an important factor in seismic hazard evaluation.

How to estimate Vs30 ?

Geophysical prospecting :

- Seismic refraction method
- Seismic reflection method
- Suspension PS logging
- Downhole logging
- Crosshole logging

$$V_{s30} = \frac{30}{\sum_{i=1}^{n} \frac{d_i}{V_{si}}}$$



Estimate from other parameters :

$V_s = aN^b D^c$	Ohta and Goto (1978)
$V_s = aN^b$	Lee and Tsai (2008)
$\ln(V_s) = \mathrm{f}(N_{60}, \sigma_v', FC, \mathrm{PI}, \mathrm{OCR})$	Tsai et al. (2019)
$logV_{s30} = a + blogV_{s(d)}$	Boore (2004)
Bottom constant velocity	Kuo et al. (2011)

D: Depth

N: SPT-N value

σ_v' : Vertical effective stress

FC: Fines content

OCR: Over Consolidation Ratio

PI: Plasticity index

CORRELATION BETWEEN Vs, e AND σ'_v (LABORATORY DATA)

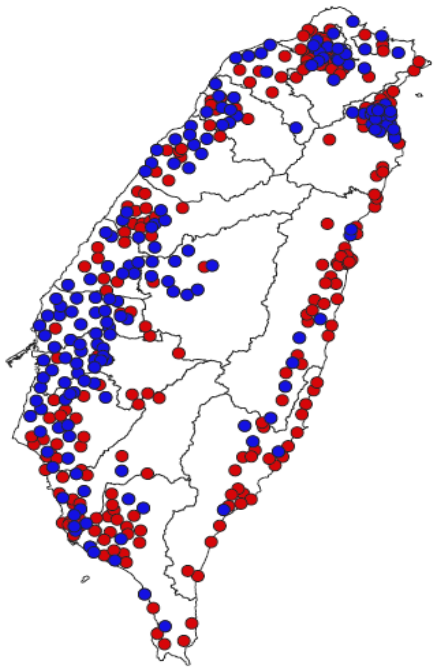
$$V_s = (m_1 - m_2 e)(\frac{\sigma'_v}{100})^{n_a}$$ Robertson et al. (1995)

e : Soil void ratio

σ'_v : Vertical Effective Stress

Gravel	$\boldsymbol{V_s = (241.6 - 39.9e)(\frac{\sigma'_v}{100})^{0.30}}$
Silt and Clay	$\boldsymbol{V_s = (199.2 - 2.9e)(\frac{\sigma'_v}{100})^{0.31}}$
Sand	$\boldsymbol{V_s = (360.6)(\frac{\sigma'_v}{100})^{0.38}}$

Kuo, 2021

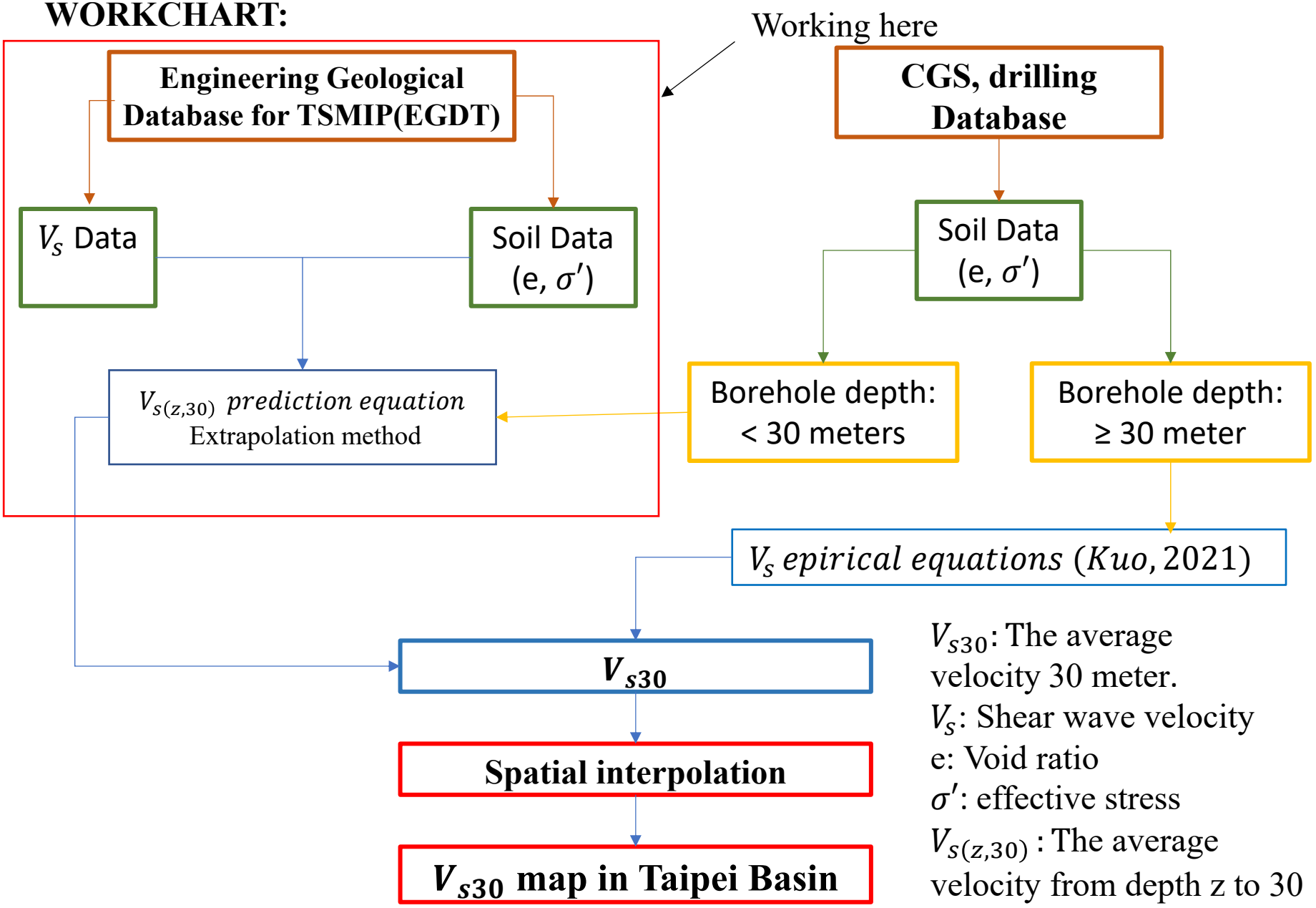


Kuo' s data used

Kuo' s data did not used

2 Methodology

WORKCHART:



V_{s30}: The average velocity 30 meter.
V_s: Shear wave velocity
e: Void ratio
σ': effective stress
$V_{s(z,30)}$: The average velocity from depth z to 30 meter.

Engineering Geological Database for TSMIP (EGDT)

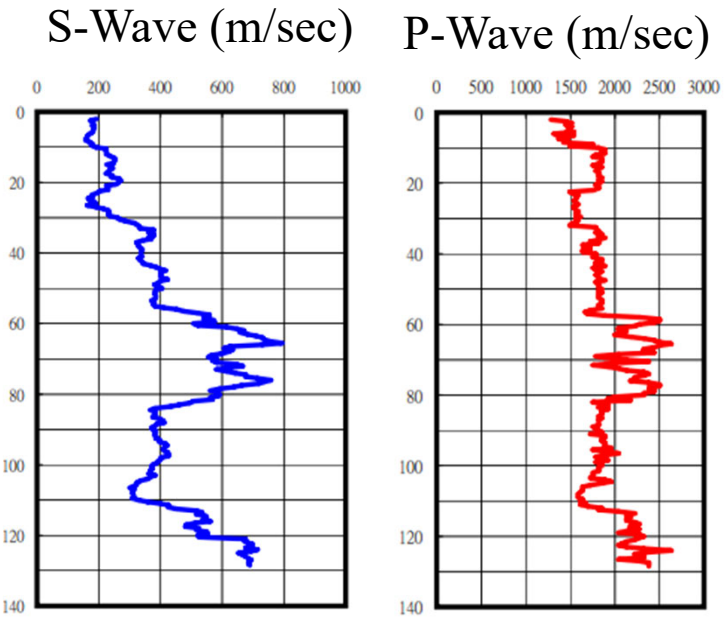
31 boreholes

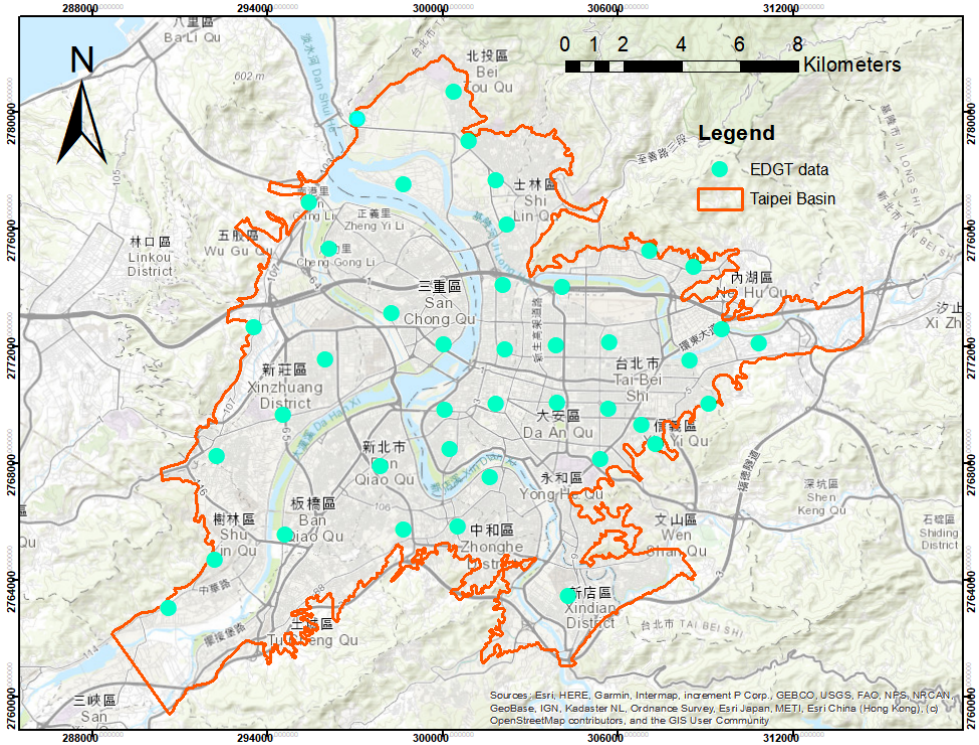
NCREE

Soil profile characteristics are determined by subsurface investigation and field/lab testing program.

➡ Soil Data(e, σ')

Suspension PS logging method





➡ V_s Data

Extrapolation methods

Bottom constant velocity (BCV) model (Kuo et al., 2009,2011)

- The assumption of model that V_s is constant from z_p to 30m

$$V_{s30} = \frac{30}{\Delta t_z + \frac{30 - z_p}{V_{s(z_p)}}} \qquad (1)$$

Δt_z the shear wave travel time from z_p to the surface

Conditional independence property model (CIP) (Dai et al.,2013)

- The assumption that the V_s profile is a Markov process staring from z =0

- The instantaneous velocity at depth z, the average velocity from surface to the depth z (V_{SZ})cannot be effectively in estimating the average velocity from depth z to 30 m ($V_{s(z_p,0)}$

$$\log(V_{s(z,30)}) = c_0 + c_1 \log V_{SZ} \quad (2)$$

c_0, c_1, : regression coefficents

- Using the average velocity from z to 30 m to estimate V_{s30}

$$V_{s30} = \frac{30}{\Delta t_z + \frac{30 - z_p}{V_{s(z_p,30)}}} \quad (3)$$

Δt_z the shear wave travel time from z_p ro the surface

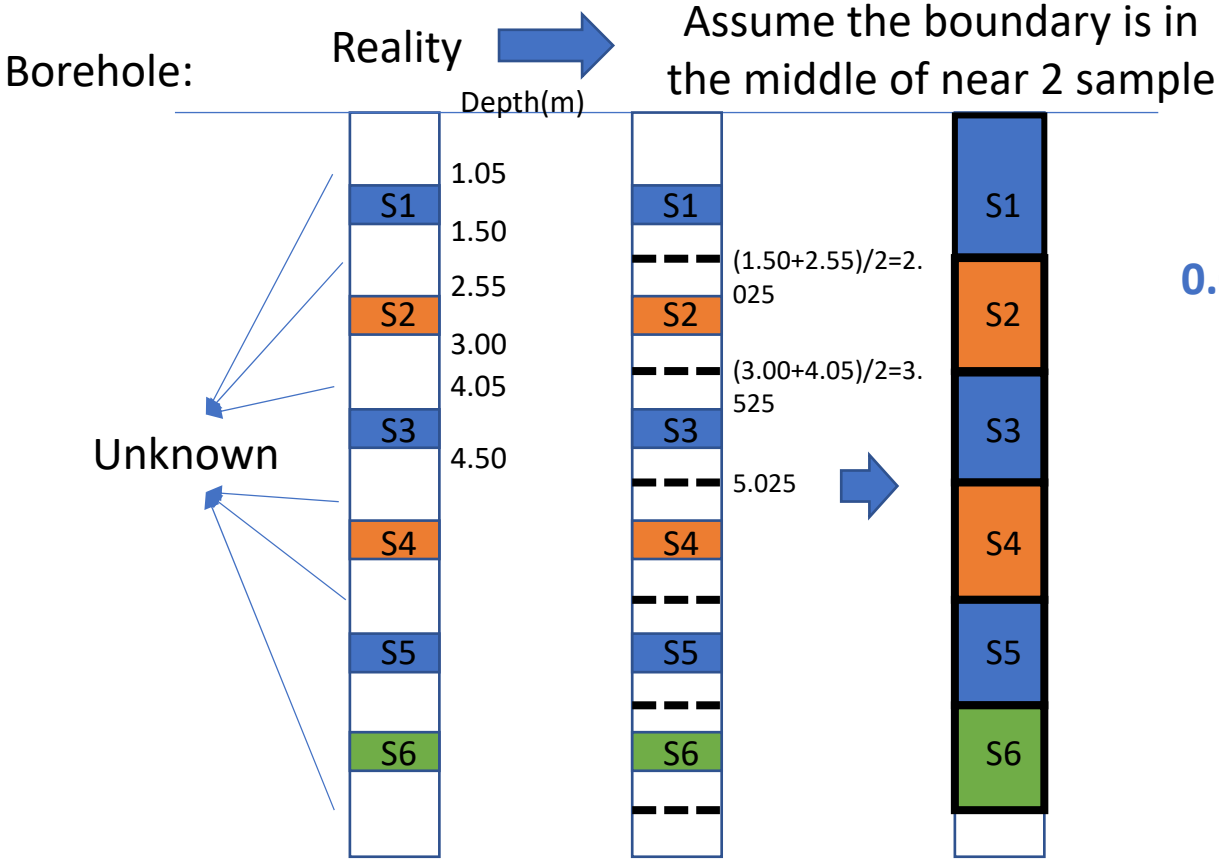
How to estimate effective stress in each borehole?

$$\sigma_v' = \sigma_v - \mu$$

Effective stress | Vertical stress | Pore water pressure

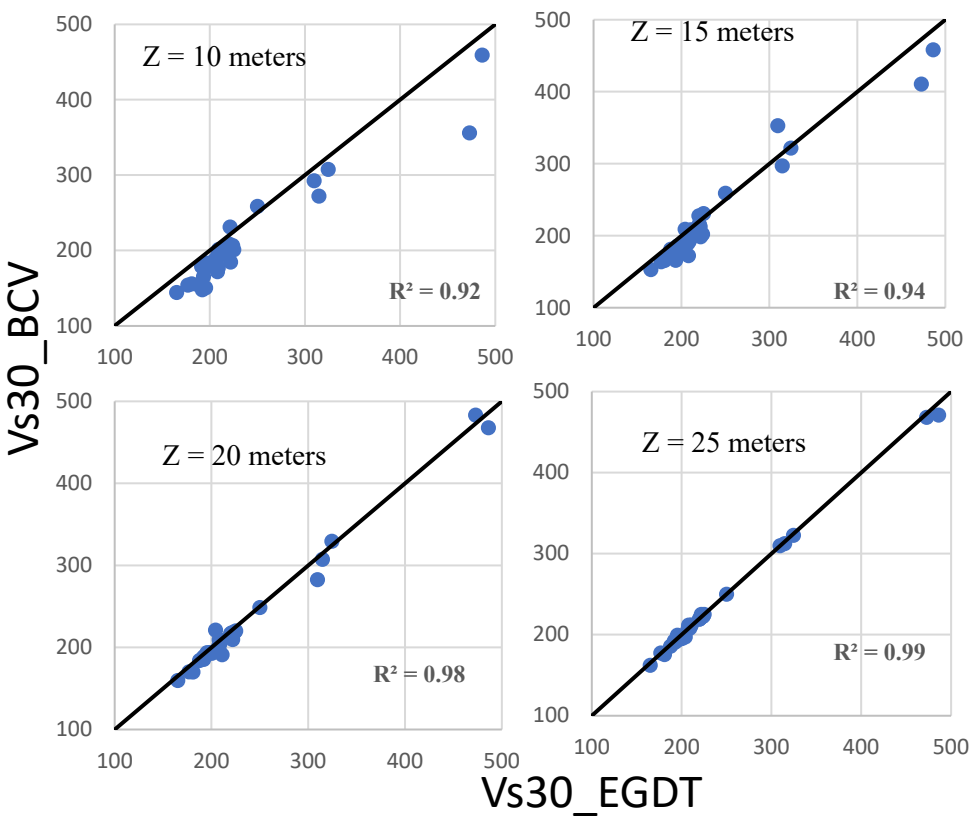
$$\sigma_v = \sum z_i \times \gamma_{ti}$$

Assume the boundary is in the middle of near 2 sample

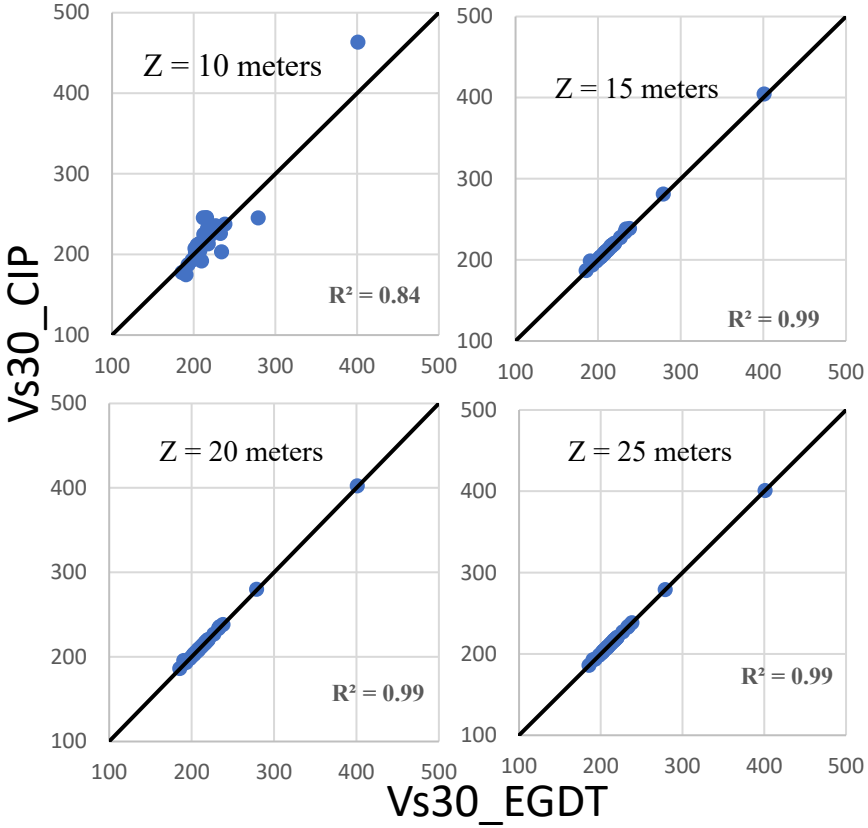


The γ_t, e of soil at 0.000-2.025m equals to γ_{t1} and e_1

3 Preliminary result



BCV MODEL



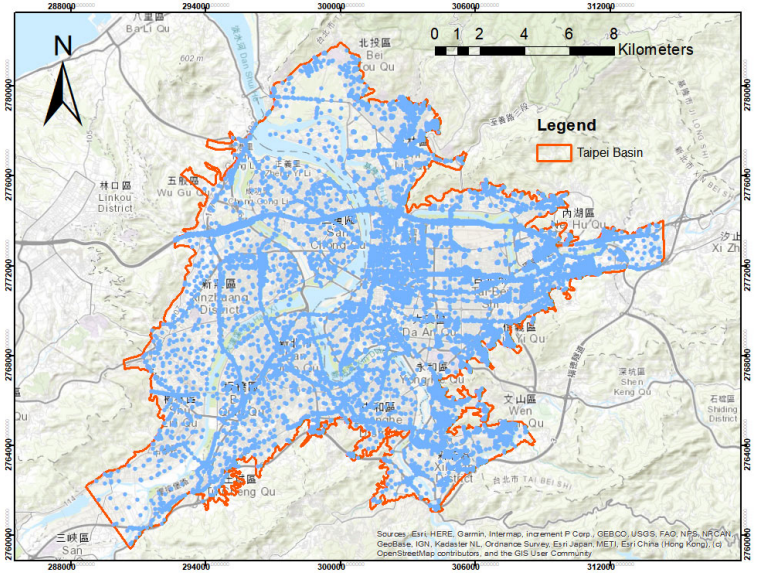
CIP MODEL

Conditional independence property model (Dai et al.,2013) is bester extrapolation method.

Z=10 -15(m): $\log(V_{s(z,30)} = 1.11 \log V_{SZ} - 0.25$ (5)

Z=15 – 29 (m): $\log(V_{s(z,30)}) = 1.01 \log V_{SZ} - 0.003$ (6)

4 Future work



經濟部中央地質調查所
Central Geological Survey, MOEA

Total: 10768 boreholes

CGS, drilling Database

Soil Data (e, σ')

Borehole depth: < 30 meters

Borehole depth: ≥ 30 meter

Extrapolation method CIP

V_s *epirical equations* (*Kuo*, 2021)

V_{s30}

Spatial interpolation

V_{s30} map in Taipei Basin

V_{s30}: The average velocity 30 meter.
V_s: Shear wave velocity
e: Void ratio
σ': effective stress

Thanks for your attention!