NUMERICAL SIMULATION OF SUBSIDENCE INDUCED BY GROUNDWATER PUMPING AT DIFFERENT AQUIFERS IN THE CENTRAL YUNLIN COUNTY

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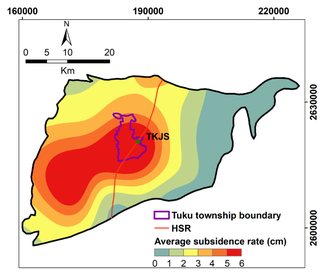
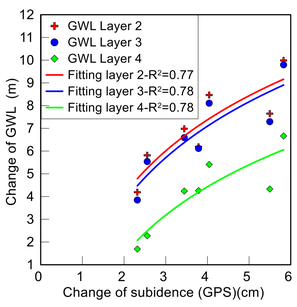
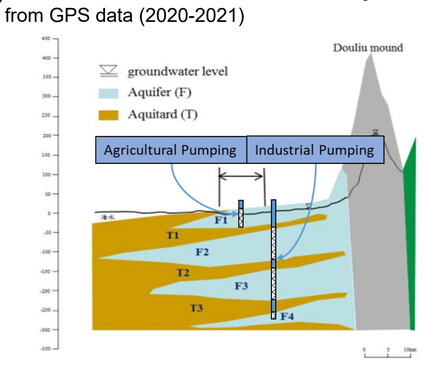
INTRODUCTION



Average subsidence rate in Yunlin county from GPS data (2020-2021)

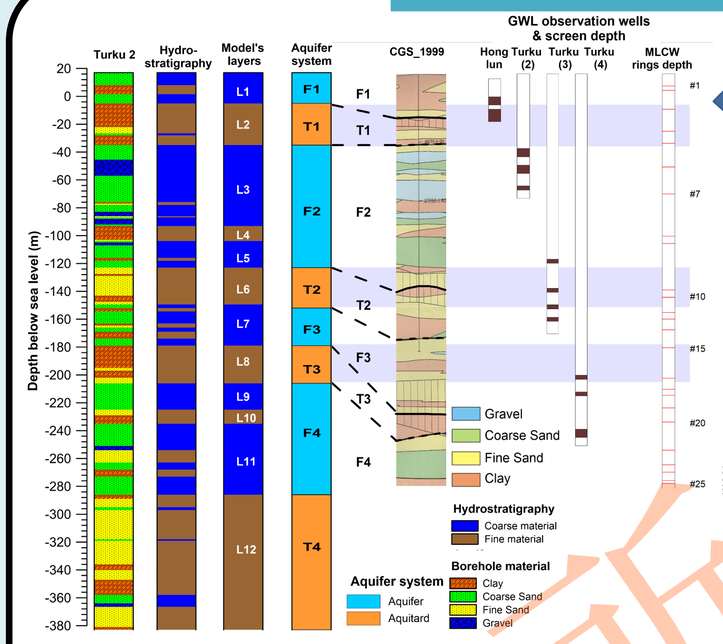




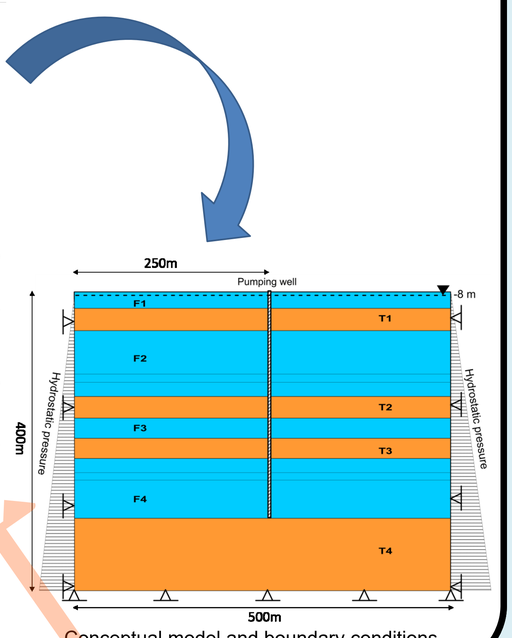
Geological setting of CRAF (modified from CGS)

Yunlin (Taiwan) subsidence has been occurring due to pumping groundwater for agriculture, industry, cosmetics with different depths of pumping wells. It is essential to determine whether pumping in shallow or deep aquifers will cause more subsidence.

NUMERICAL MODEL



Define aquifer system for numerical modeling



Conceptual model and boundary conditions

OBJECTIVES

- Determine the contribution of each layer compaction to the total land subsidence.
- Determine pumping in shallow/deep aquifers leading to more subsidence when applying the **same pumping rate.**

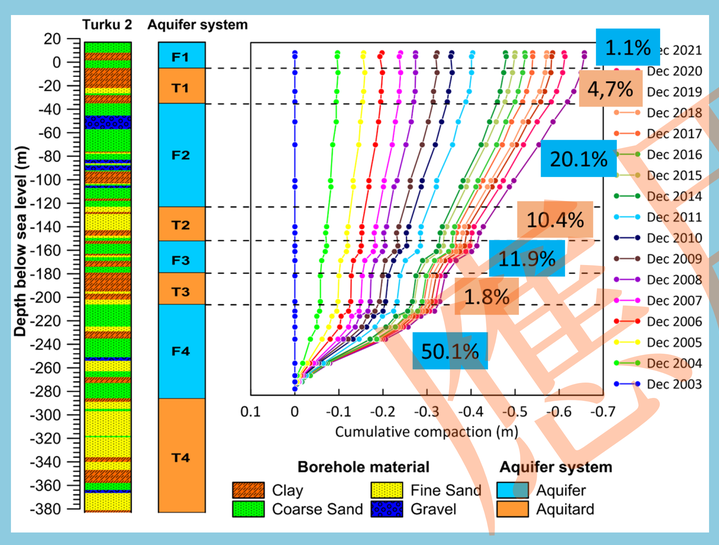
METHODOLOGY

A coupled fluid-mechanical model with Mohr-Coulomb criteria, using the finite difference method in FLAC3D software is employed to assess the effect of pumping shallow/deep aquifer to total land subsidence.

RESULTS

Observation data

Contribution of compaction for different aquifers



Calibrated parameters for numerical model

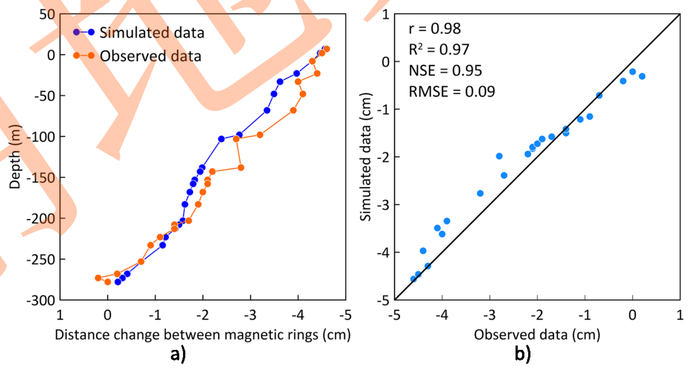
*Initial value (WRA, 2020) *Reference values

Soil layers	K (Pa)	G (Pa)	n	k (m/s)	c (Pa)	φ(°)	ψ(°)
L1	3.09E+07	1.43E+07	0.3	2.31E-05	1E+01	20	7
L2	4.29E+07	1.98E+07	0.52	4.16E-08	3E+03	1	1
L3	4.17E+07	1.92E+07	0.3	1.68E-05	1E+01	25	4
L4	4.58E+07	2.12E+07	0.4	1.68E-08	9E+03	1	4
L5	4.17E+07	1.92E+07	0.3	1.68E-05	1E+01	25	4
L6	5.00E+07	2.31E+07	0.4	2.52E-08	9E+03	1	-
L7	5.83E+07	2.69E+07	0.3	1.88E-05	1E+03	17	-
L8	3.33E+08	1.54E+08	0.4	8.31E-08	6E+03	1	-
L9	3.33E+07	1.54E+07	0.3	1.69E-05	1E+01	19	-
L10	3.33E+08	1.54E+08	0.4	1.69E-08	1E+03	1	-
L11	3.33E+07	1.54E+07	0.3	1.69E-05	1E+01	19	-
L12	3.33E+08	1.54E+08	0.36	1.94E-08	1E+03	1	-

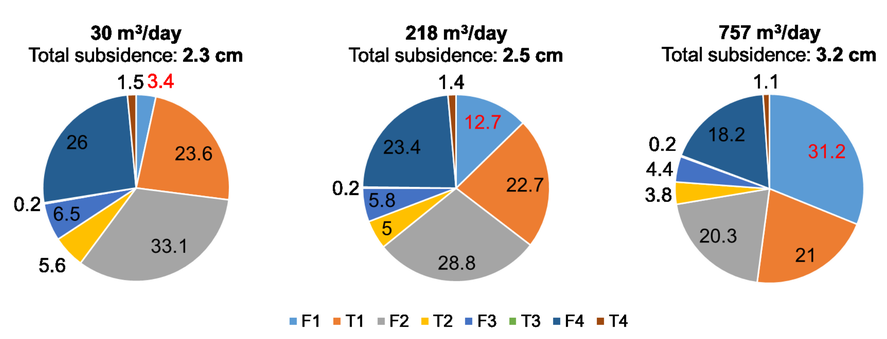
Note: K = elastic bulk modulus ; G = elastic shear modulus ; c = cohesion ; φ = friction angle; ψ = dilation angle; n = porosity; k = hydraulic conductivity.

Numerical simulation

The effect of pumping at shallow/deep aquifers on land subsidence

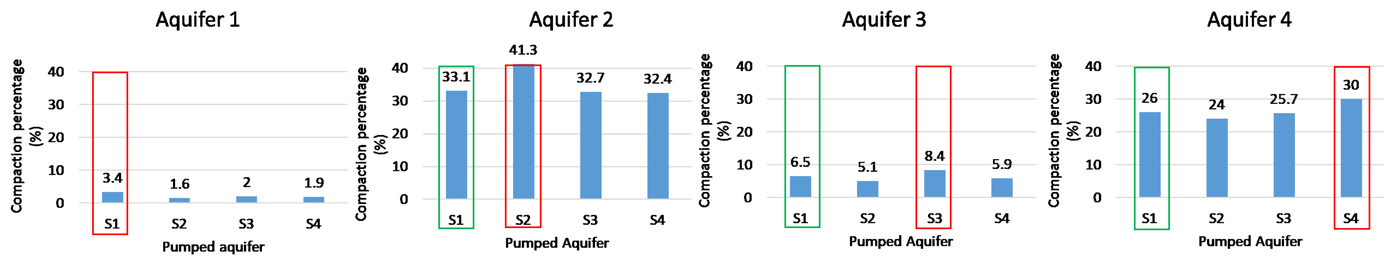


a) Comparison between observed and simulated data of distance change at 25 magnetic rings of MLCW
b) Observed and simulated data of distance change at 25 magnetic rings of MLCW



Compare compaction percentage (%) of all layers when pumping at Aquifer 1 by different pumping rates

Comparison of total land subsidence caused by pumping at four aquifers by different pumping rates



Comparison of compaction percentage of four aquifers caused by pumping at different aquifers (pprate: 30 m3/day)

CONCLUSIONS

- Aquifers 2 & 4 contribute > 70% to the total land subsidence due to clay-interbedded layers & thicker thickness
- Fluid-mechanical model captured the compaction behavior due to GW pumping
- The higher pumping rate, the more compaction in the pumped aquifer and more land subsidence
- Pumping at aquifer 2 (depth interval 40 – 120m) caused the most land subsidence.
- Pumping at shallow aquifer caused more compaction on other aquifers, pumping at deep aquifers mainly affected themselves a lot.