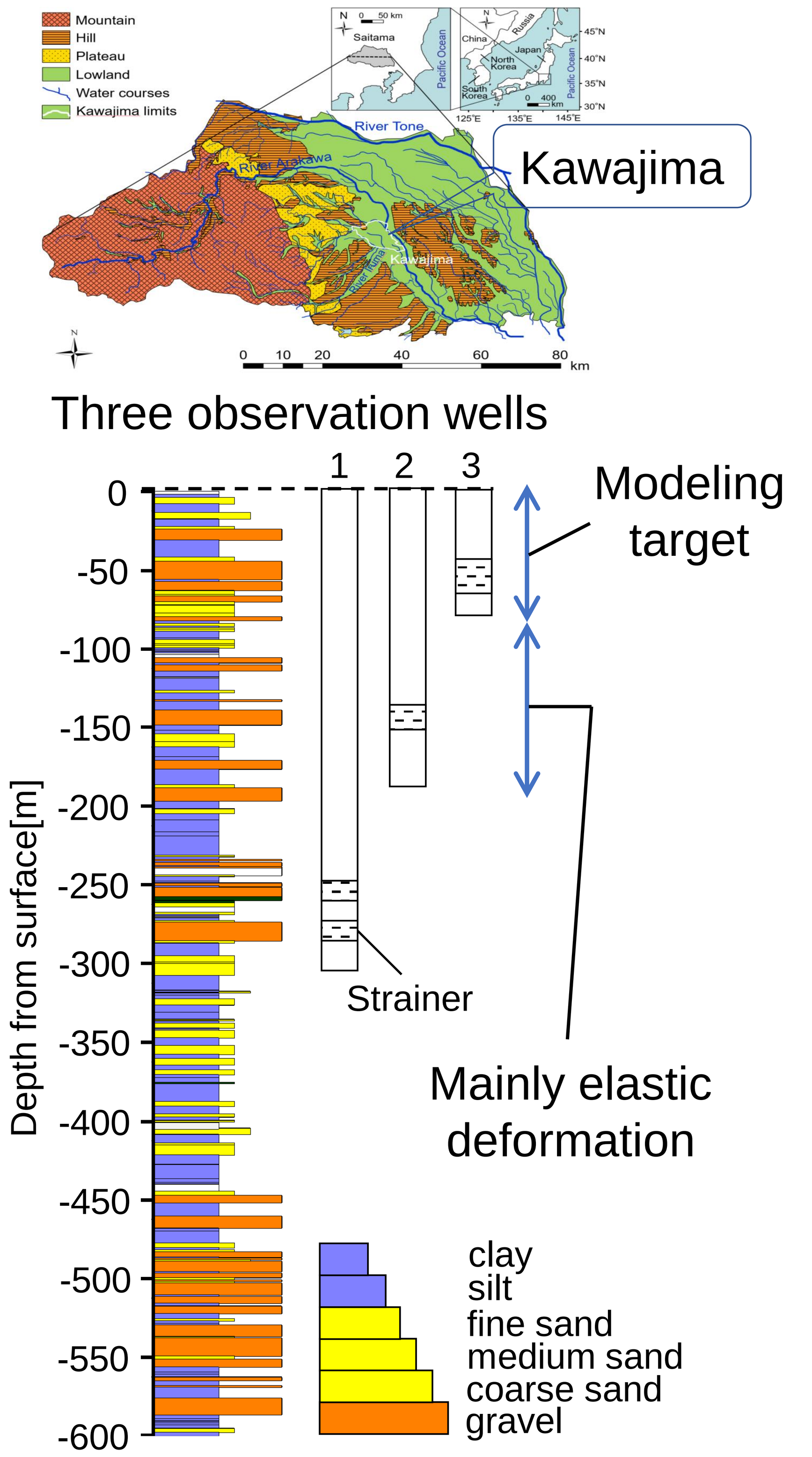
One dimensional numerical modeling of land subsidence caused by seasonal groundwater level fluctuations in Kawajima, Japan

Kento Akitaya, Masaatsu Aichi
The University of Tokyo
k.akitaya@envsys.k.u-tokyo.ac.jp

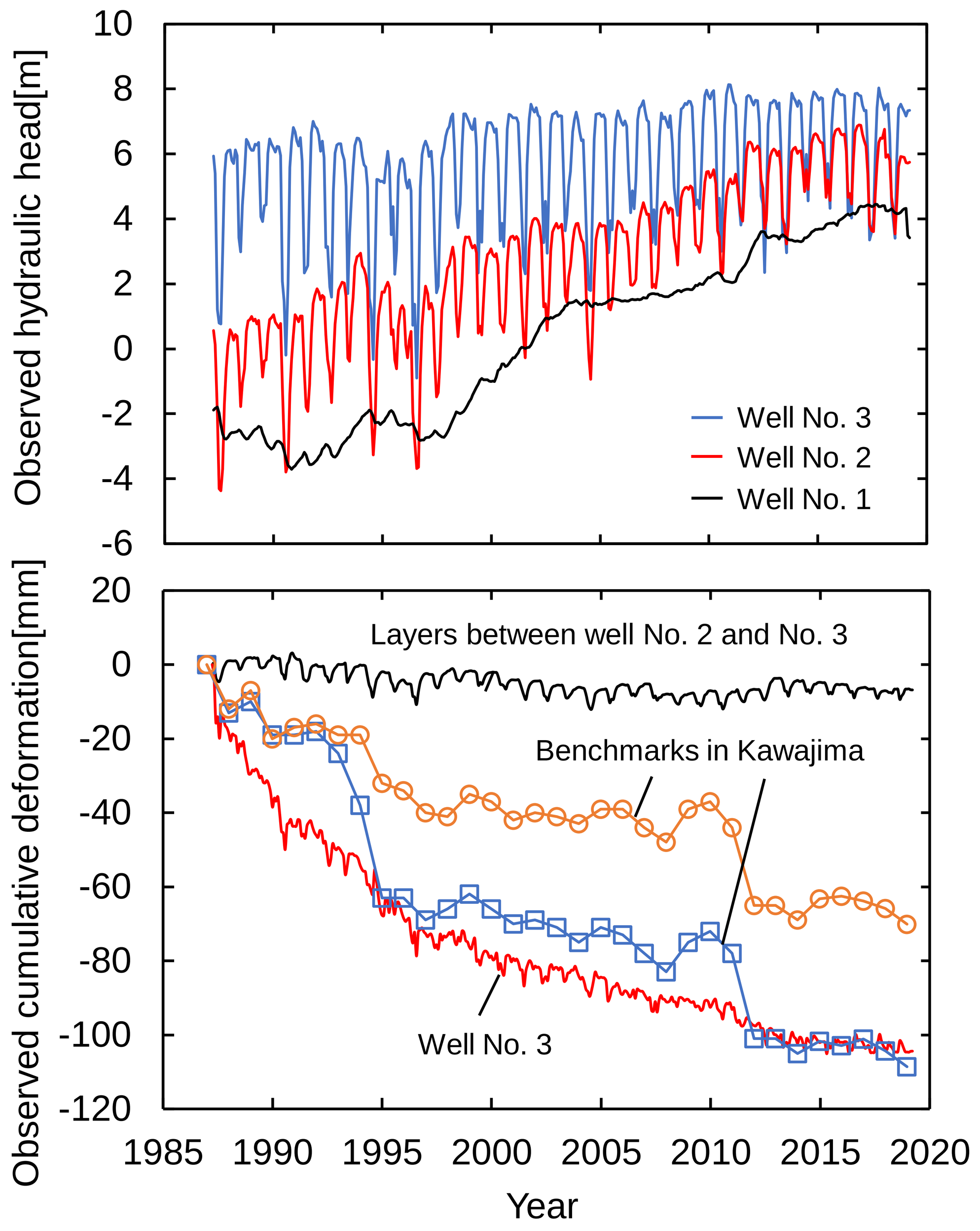
Main purpose: Developing a model to simulate land subsidence caused by seasonal groundwater level fluctuations caused by agricultural groundwater use.

Conclusion: Model succeeded to reproduce observed subsidence.
Future work: Separation of subsidence caused by earthquake.

INTRODUCTION



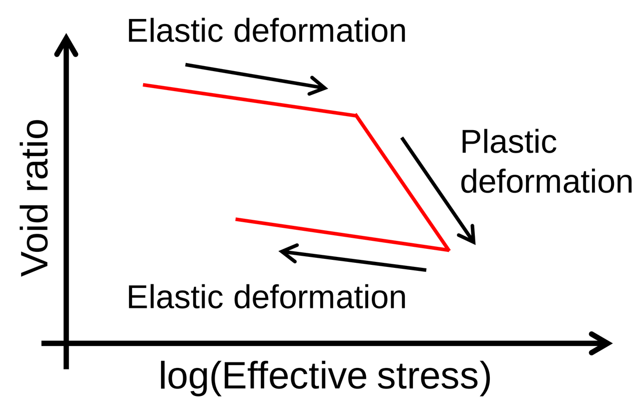
- Groundwater level is increasing in the long term
- Land subsidence has cumulatively progressed
- Plastic deformation is concentrated from 0 m to 80 m depth



METHODOLOGY

$$\frac{\rho}{1+e_0}\left(S_e\frac{\partial e}{\partial t}+e_0\frac{\partial S_w}{\partial t}\right)+\frac{\partial}{\partial z}\left[-Kk_r\left(\frac{1}{g}\frac{\partial p}{\partial z}+\rho\right)\right]+\rho Q=0$$

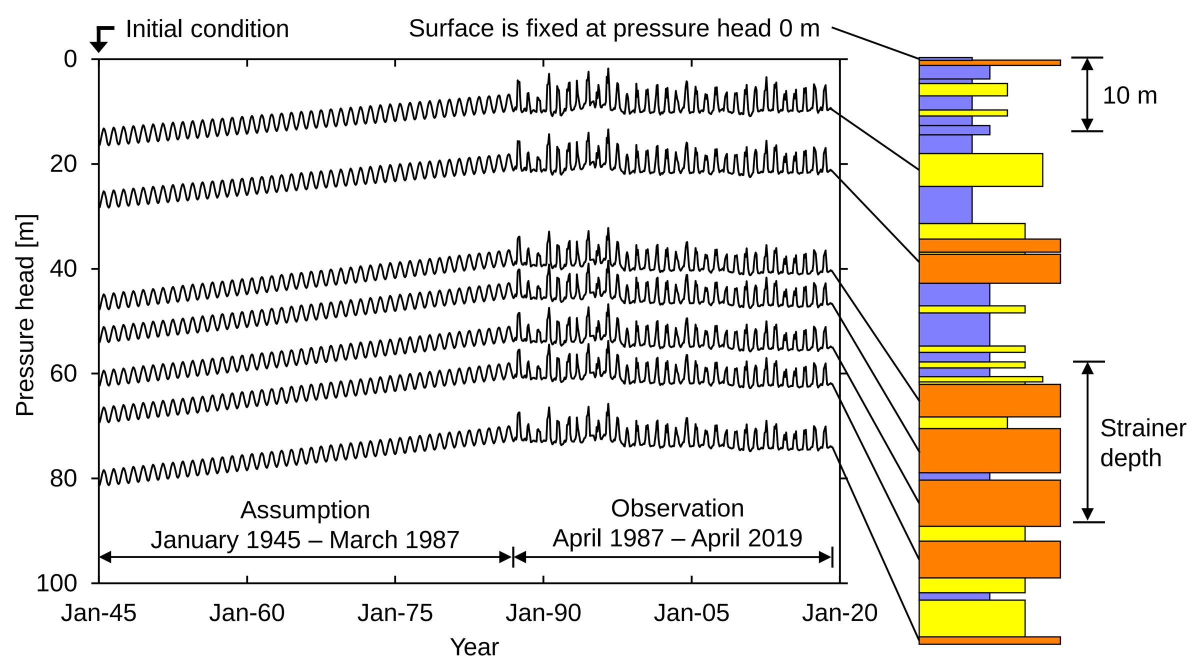
ρ: water density, e_0: initial void ratio, e: void ratio, S_e: effective saturation, S_w: saturation, K: hydraulic conductivity, k_r: relative permeability(Mualem model), p: pore pressure, Q: pumping rate



Modified Cam-clay model: The plastic deformation is described by the modified Cam-clay model.

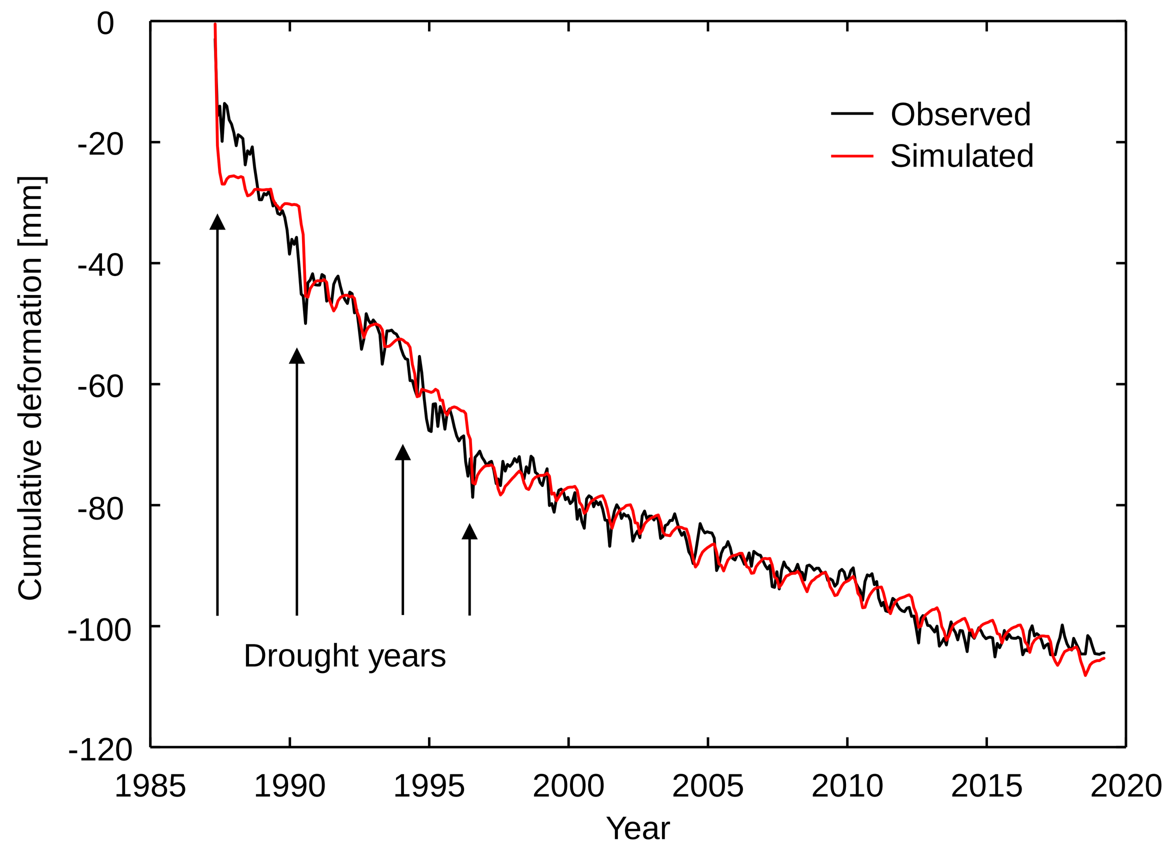
Parameter search by genetic algorithm

- Hydraulic conductivity
- Specific storage
- Compression index
- Solid density
- The past maximum burial depth

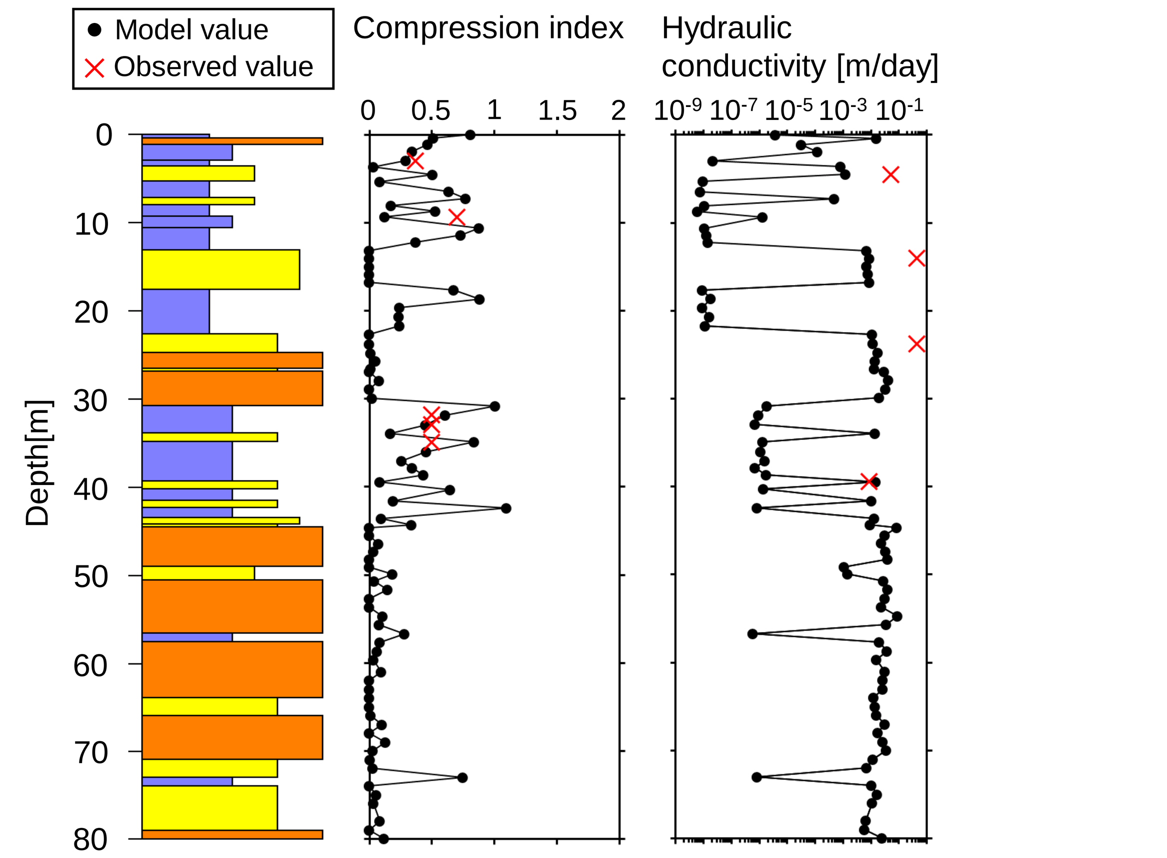


Initial and Boundary Condition: Pore pressure values are specified as initial and boundary condition. Initial pressure distribution is assumed to be hydrostatic. Pore pressures in aquifers without observation were estimated by interpolation and extrapolation from observations at well 2 and 3.

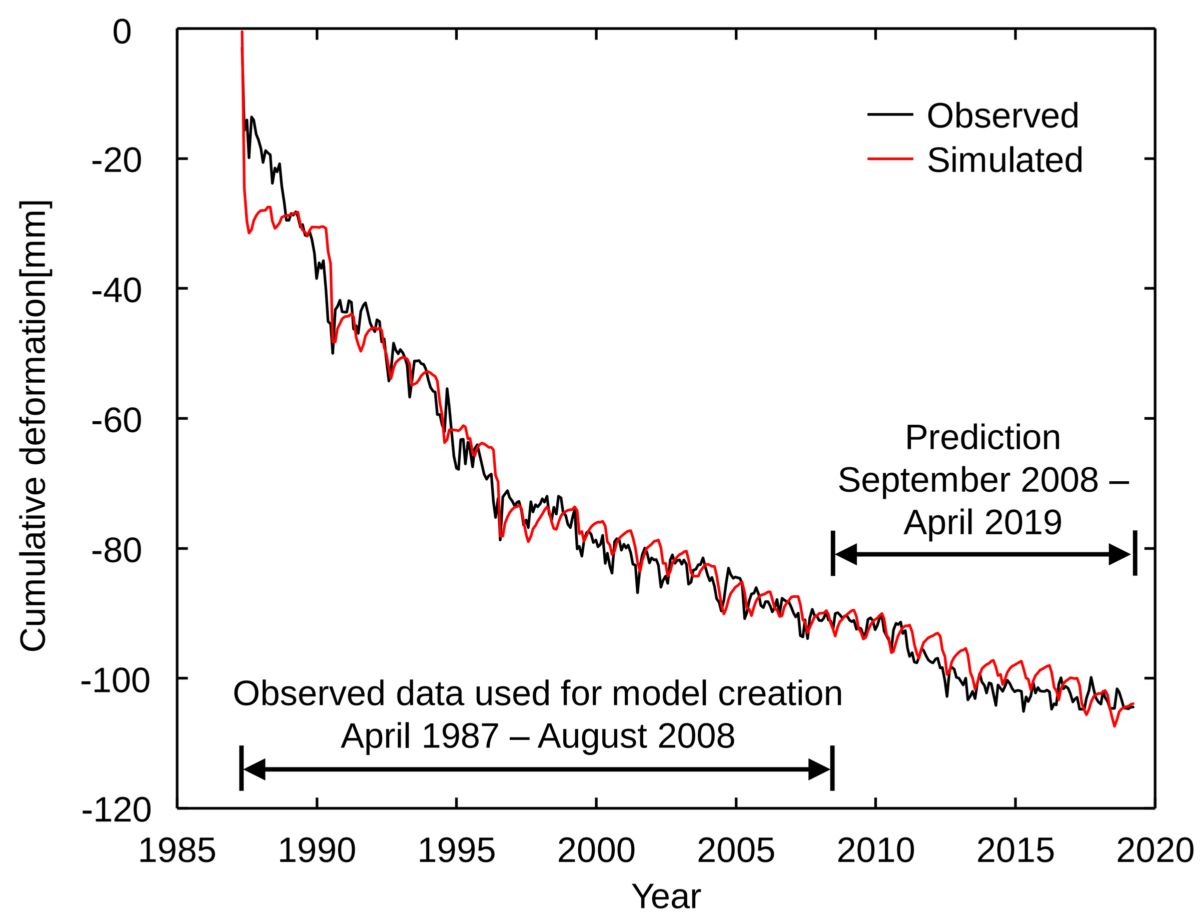
RESULTS and DISCUSSION



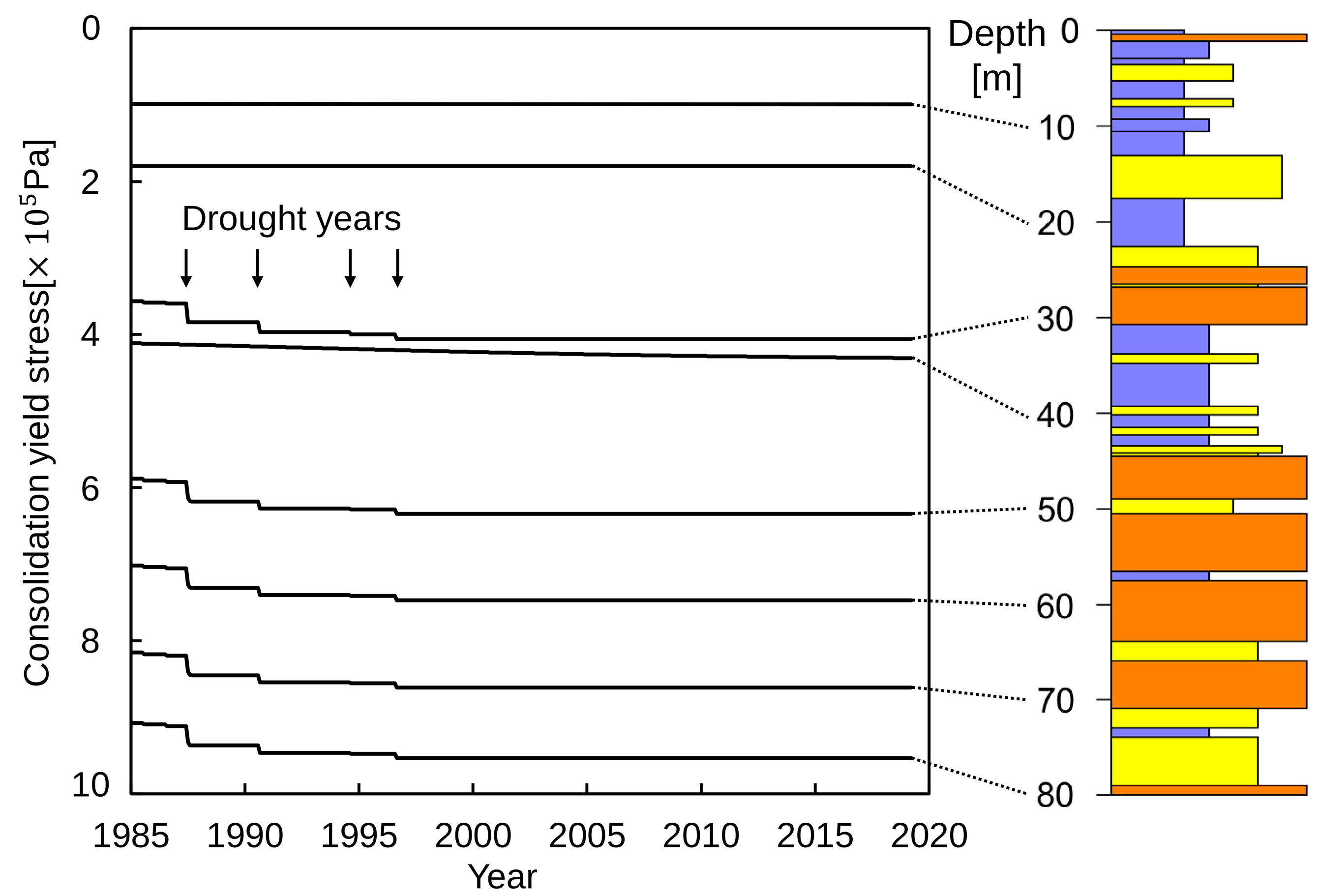
Observed and simulated subsidence: Simulated subsidence overall agrees with observed subsidence. Model successfully reproduced seasonal expansion and contraction. Significant subsidence is found in drought years, which reflects changes in groundwater demand.



Model parameter: Model parameter was consistent with observed values.



Predictive errors: To test model's predictive performance, another model was calibrated using the first two-thirds of the observed data. Then, subsidence was predicted for the remaining one-third. The fit of the simulated and observed subsidence has not been good since 2011. One possible reason is the impact of land subsidence caused by the March 2011 earthquake.



Yield stress of consolidation: Yield stress of consolidation changes only when plastic deformation occurs in clay and silt layers. Here, however, significant changes in yield stress of consolidation was estimated in sand and gravel layers. This could be interpreted that the existence of thin clay or silt layer in sand and gravel layers are important for the short term plastic deformation in seasonal groundwater level change.

REFERENCES and ACKNOWLEDGEMENTS

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