Decadal trends in groundwater quality observed in national groundwater monitoring wells - assessment of climate change effects using machine learning.

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Knowledge gap:

The linkages between climate change and groundwater quality and the subsequent effects.

Aim of the study:

Understand how climate change can affect groundwater quality through changes in hydro-geochemistry induced by shifting temperature, precipitation, and evapotranspiration.

Initial outcomes:

- Groundwater quality is changing as major factors (temperature, pH, O_2) change through time.
- Observed O_2 concentration is decreasing faster than the modelled O_2 potentially due to accelerated microbial activity within the aquifer.

Data and Methods

- 844 wells and 1230 well intakes across Denmark with recent data (2017-2022).
- 284 wells and 476 well intakes across Denmark with long-term data (30 years or more).
- Statistical analysis.
- Calculation of dissolved oxygen concentration derived from temperature measurements by applying Henry's law to oxygen dissolution.

Next steps:

- Further data analysis and cleaning of hydrogeological data, climate data and other environmental variables, such as soil, topography, and land use.
- Distinguish the impacts of climate change from human-induced changes.
- Apply machine learning to identify the main drivers of change and predict spatial and temporal variability of groundwater quality in Denmark.

Figure 1: Maps of Denmark.

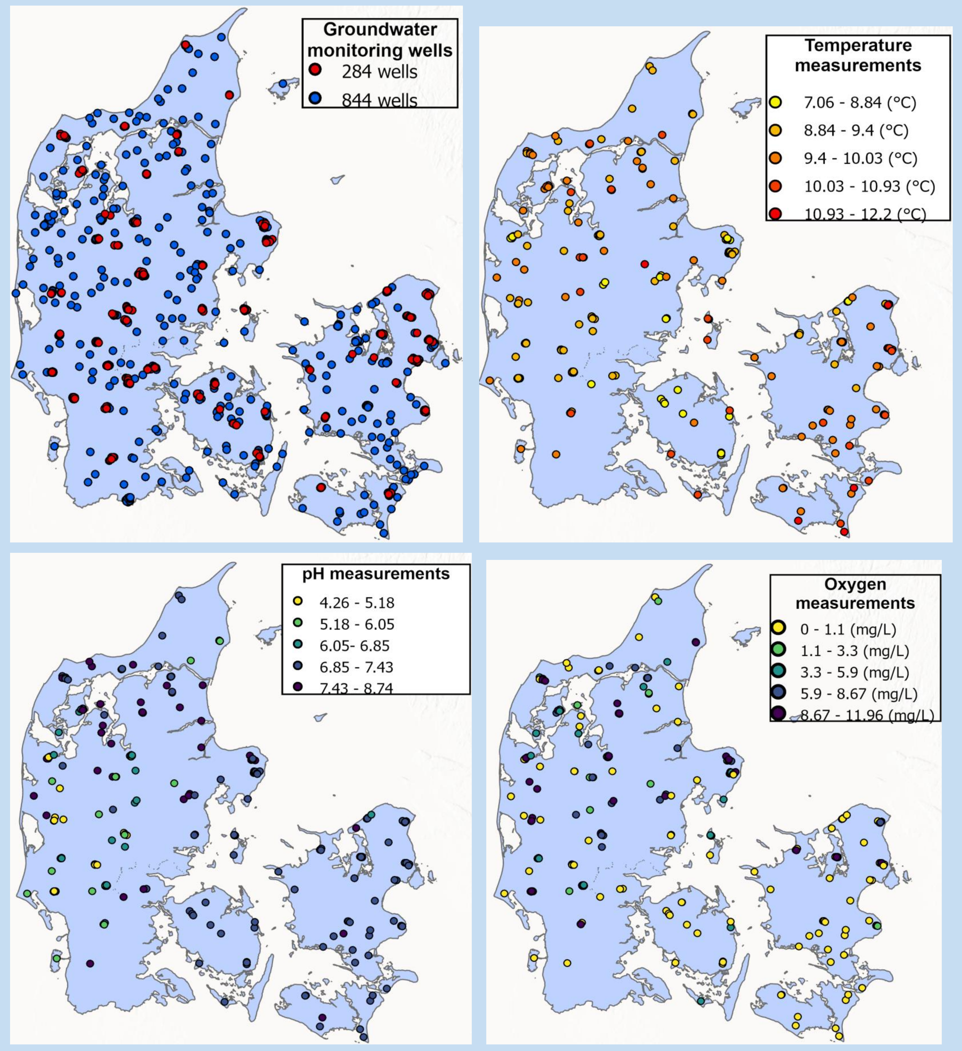
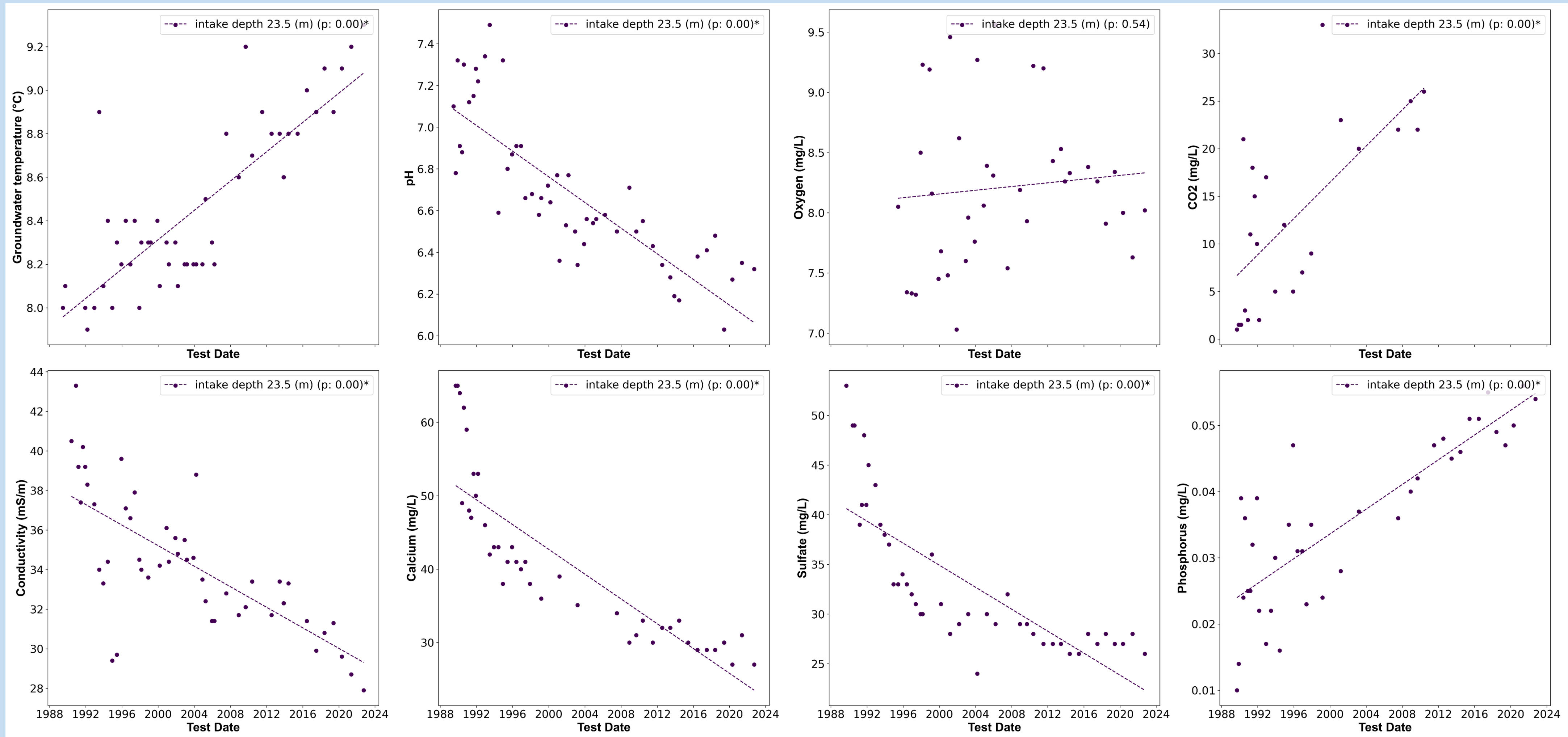


Figure 2: Example of groundwater quality measurements.



Results

a) Changes in groundwater temperature, pH and observed O_2 concentration are different at different depths. In most well intakes, groundwater temperature increases with a stronger increase in the shallow wells. In contrast, the observed O_2 concentration has the smallest decrease in the deep well intakes (>25m) than in the shallower ones (Figure 3).

b) From all measurements during the long-term period from 1988 to 2022, changes (Δ) in groundwater temperature (T), pH and O_2 show a significant increase for T and a significant decrease in pH and observed O_2 concentration (Figure 4).

c) Comparison between observed O_2 and modelled O_2 concentration indicates that the in-the-field O_2 concentration decreases faster than the modelled (Figure 4).

Figure 3: Stacked histogram of slopes for 3 different depth groups.

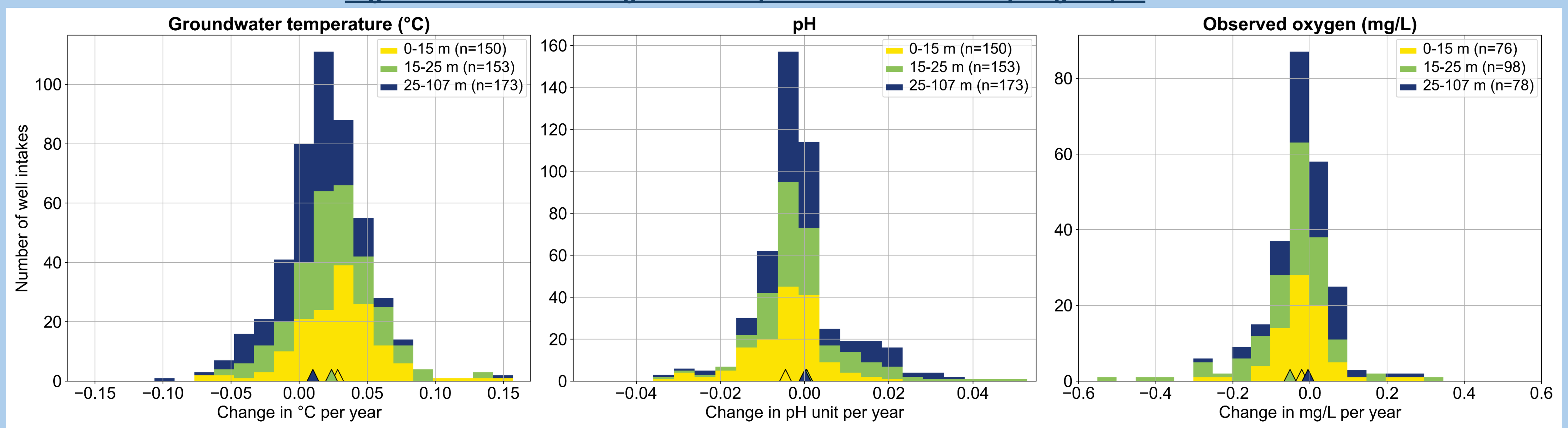


Figure 4: Anomaly plots for T, pH, observed and modelled oxygen.