Isotope mapping of groundwater pollution and renewal

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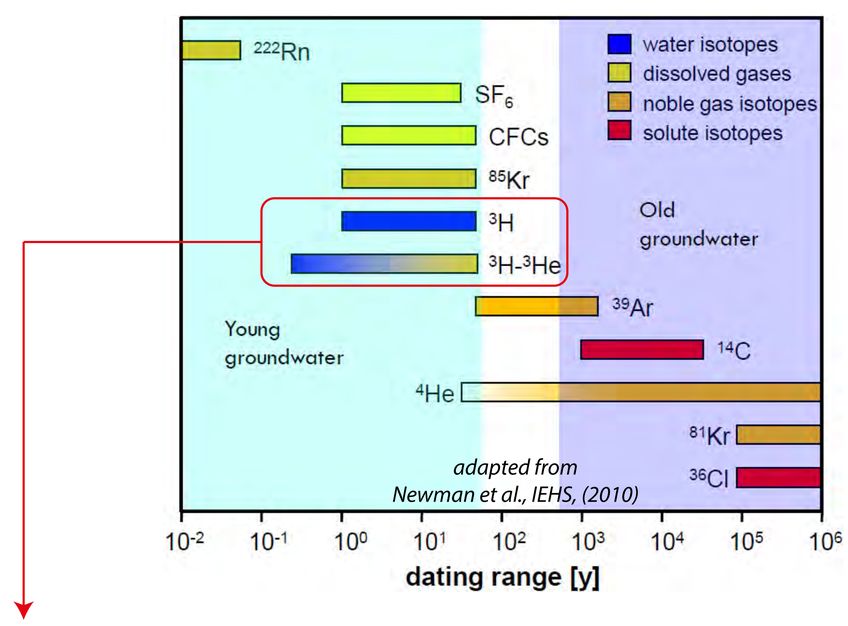
Motivation

- Provisioning of groundwater and its quality are increasingly significant issues in light of growing population, increasing standard of living, climate change
- Groundwater supplies 50% of drinking water worldwide and 43% of agriculture irrigation
- Groundwater quality is affected by:
  - Anthropogenic influences – fertilizer and pesticide application, chemical spills, fecal contamination, over-extraction
  - Natural conditions – toxic levels of geogenic contaminants (e.g. As, F) released under certain geochemical conditions
- Creation of models/maps provides means to identify sensitive areas and to readily communicate results to stakeholders

Groundwater dating with isotopes



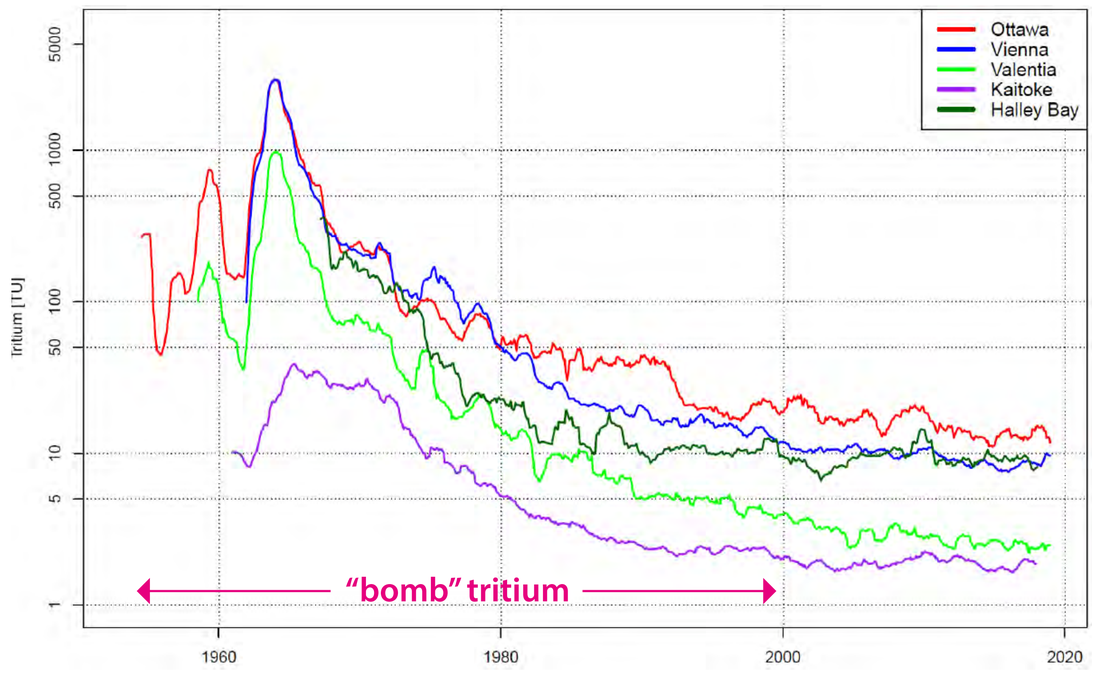
Tritium (^3H)

Half-life of 12.32 years
Dating tracer to assess "young" groundwater (^3H, ^3H+^3He)
Used to map renewable water resources and vulnerability

Pros:
- Part of the water molecule ("ideal" tracer), straightforward sampling
- Simple qualitative use, few alternatives for young groundwater
- Relatively constant values in precipitation for the last ~20-25 years

Cons:
- Analytical challenge due to very low activities in nature and few labs
- Necessary assumptions of groundwater flow, unclear representativeness
- Need to know contemporary ^3H levels in precip. or tritium input function

Tritium input functions



Time series of tritium in rainwater from the IAEA's Global Network of Isotopes in Precipitation (GNIP)

Tritium distribution in the atmosphere is affected by proximity to the poles, elevation, air currents and the presence of continents

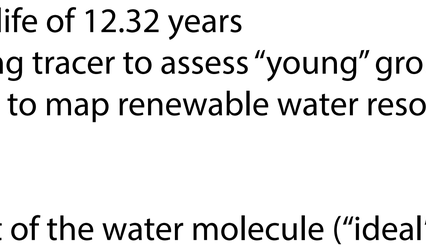
Differences are therefore observed, for example, by latitude and northern vs. southern hemisphere

Atmospheric nuclear bomb testing starting early 1950's injected huge amounts of ^3H into the atmosphere (and water cycle)

Geospatial machine learning modelling

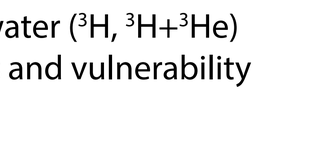
Create map of target parameter, e.g. groundwater vulnerability or recharge

Target parameter



Point data containing:
- measurements
- geographical coordinates

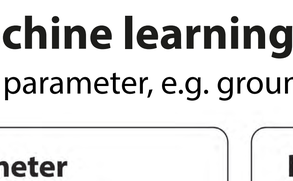
Predictor data



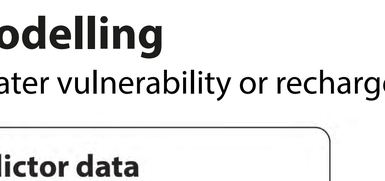
- spatially continuous
- resolution of predictors determines resolution of output

Machine learning modelling

Many possible methods: logistic regress, random forest, generalized boosted regression, support vector machines, etc.

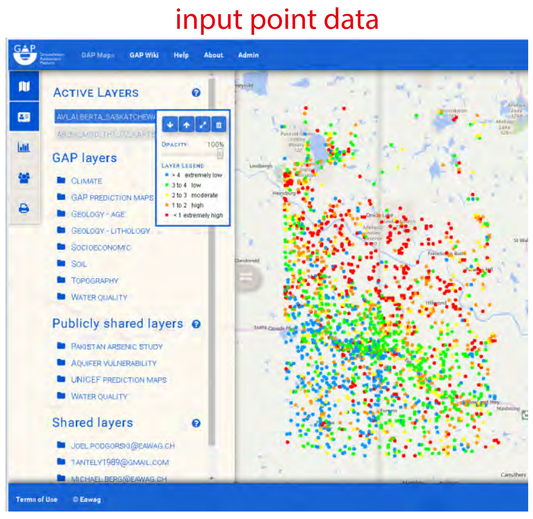


Prediction map of target parameter



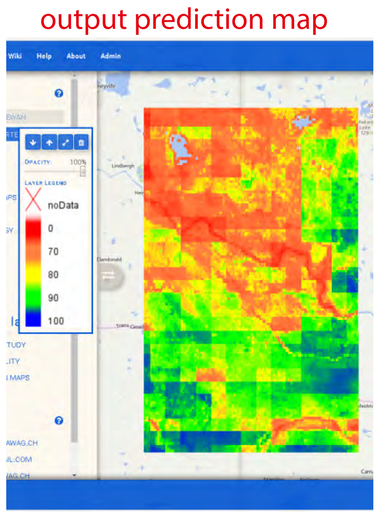
Test of modelling groundwater vulnerability

input point data



Aquifer Vulnerability Index (AVI)
AVI < 1 (red) means extremely high aquifer vulnerability; based on water table depth and aquifer sediment size measured in-situ

output prediction map



Probability of AVI > 1
Low probabilities (red) mean high vulnerability
Predictors: aridity, clay content, precipitation, slope

GAP Groundwater Assessment Platform

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-> Tritium could be used as the input target parameter; in general, more tritium means greater aquifer vulnerability