A Social Dynamics Dependent Water Supply Well Contamination Model

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Motivation

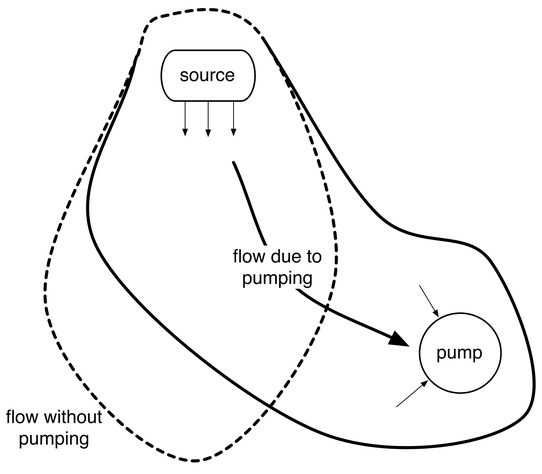
- Contaminant concentration of water in supply wells located near contaminated aquifers can depend on the rate of pumping at those wells.
- Pumping rate in turn depends on social decisions of how much water is being used from those supply wells.

Problem Statement

Three social models are used to simulate this problem in an attempt to capture all possible social scenarios under certain circumstances. The model is coupled with FEHM to calculate the flow field of Chromium Cr^{6+} in the aquifer and the contaminant concentration at the supply well throughout 50 years. The basic social model assumes:

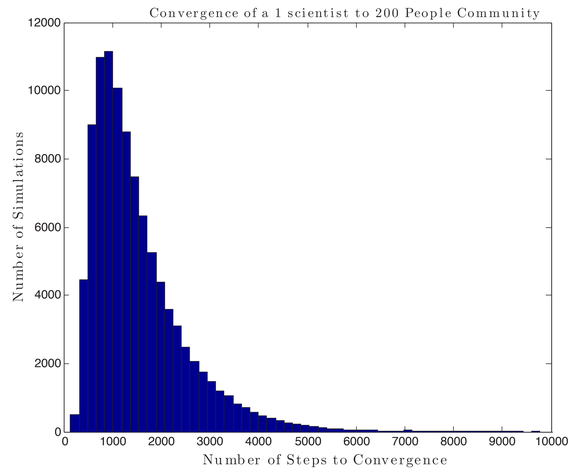
- Each individual has 2 attributes: Belief and Usage, modeled as two bits.
- All models use the concept of consistency and conformity, presented in [1], as the driving forces of social behavior.
- Consistency matches one's own attributes together. Conformity matches one's attribute with a randomly chosen other.

Basic Scenario



The Scientist Model

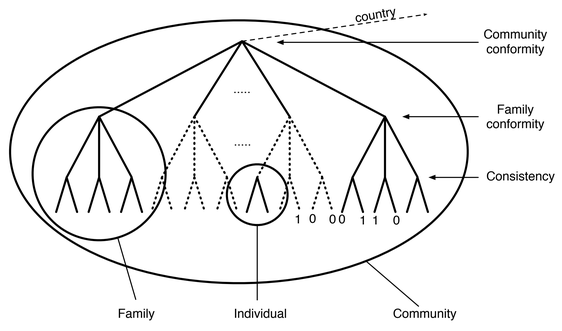
The consistency-conformity model has a set of people (here called scientists) with fixed beliefs that spread to the rest of society through conformity. This model converges to a fully consistent-conformant society that believes and does not use water from that supply well.



for a 1 to 200 scientist to population ratio, the mode of steps for convergence is around 1000.

The Stratification Model

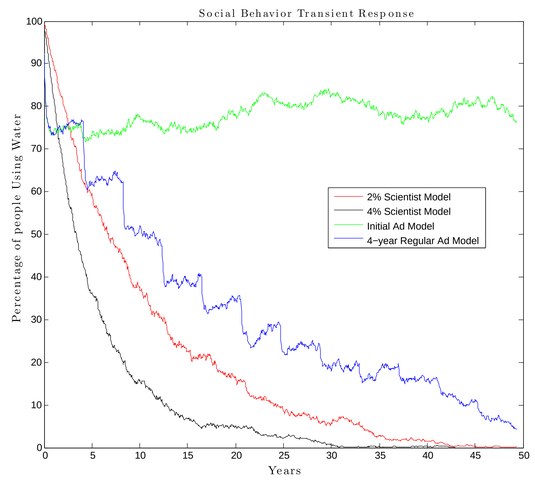
A generalized consistency-conformity model extended to a stratified consistency model where the probability of interaction is inversely proportional to the size of the social circle. That is, the probability of interacting and conforming with one's own family is higher than the probability of interacting with one's larger community etc.



- The advantage is that it is not assumed that people meet randomly and thus local conformity is allowed,
- The disadvantage is that a network approach adds uncertain variable to the system without gaining much further insight

Comparing Models

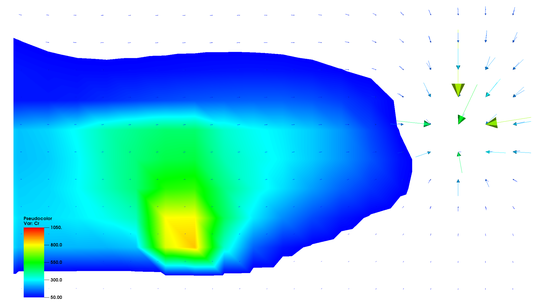
- When an initial informative event is given at the beginning of a simulation where everybody uses the water initially, the concentration percentage of people using the water stays around the same for a large enough society (in this case 10000 individuals). However, it tends to converge to the more abundant usage for a large enough time.
- When regular informative events are given, here every 4 years, usage decreases in steps until it reaches around 20% where it decreases linearly independently of informative events.
- The scientist model converges to a fully conformant consistent society with a rate proportional to the ratio of scientists to the total population. Comparing the blue and the red curves it can be noticed that when scientists are doubled, the initial slope doubled.



The Ads Model

- In a realistic consistency-conformity model, law enforcing policies or informative events broadcast to a random portion of the population who may end up believing that the water is contaminated.
- This scenario is extended to a non-convergent model where informative events are generated in case too much water is being used and usage is facilitated by market forces in case too little water is being used.

Coupled Model Results



Implementation

- The basic code for social interaction is implemented in Julia coupled with data provided by FEHM.
- Applications of such coupling are not limited to groundwater problems
- The social simulation is **embarrasingly parallel**

Conclusions

- A combined ads-stratification model works best for regulating water use from a supply well
- Climate change and social belief in such changes is another important application
- Combining social models with water contamination problems provides a useful insight for predicting policy impacts and time for social response.

References

1. Jenna Bednar et. al *Conformity Consistency and Cultural Heterogeneity* (in submission)
3. MADS: http://mads.lanl.gov