Participatory Simulation

Applications of Agent Based Modeling

- Scientific
  - Answering scientific questions via Simulations
- Engineering
  - Tools for Operational Research and Decision Support
- **Pedagogical**
  - For educational purposes, to enable people to understand concepts

Participatory Simulation

- Is the creation of Simulation that incorporates inputs from Human agents along with simulated agents
- For instance, you can think of incorporating Participatory simulation in disease model.
  - The Agents (using Human-in-loop) can actively try to avoid catching the disease

Participatory Simulation (Full Autonomy vs Participatory)

- Autonomy
  - Simple behavior Programmed into agents
  - Their state determines (also may be random chance) decision making
  - Except for initialization the experimenter have no control over the agent behavior
- Participatory
  - Human in the loop decision Making
  - In tandem with agent decision making
  - May sometimes even play “full role” of one or a collection of agents

Question to Audience

But, What exactly is 'Participatory Simulation' ? your thoughts?

Just another fancy name for games with educational value

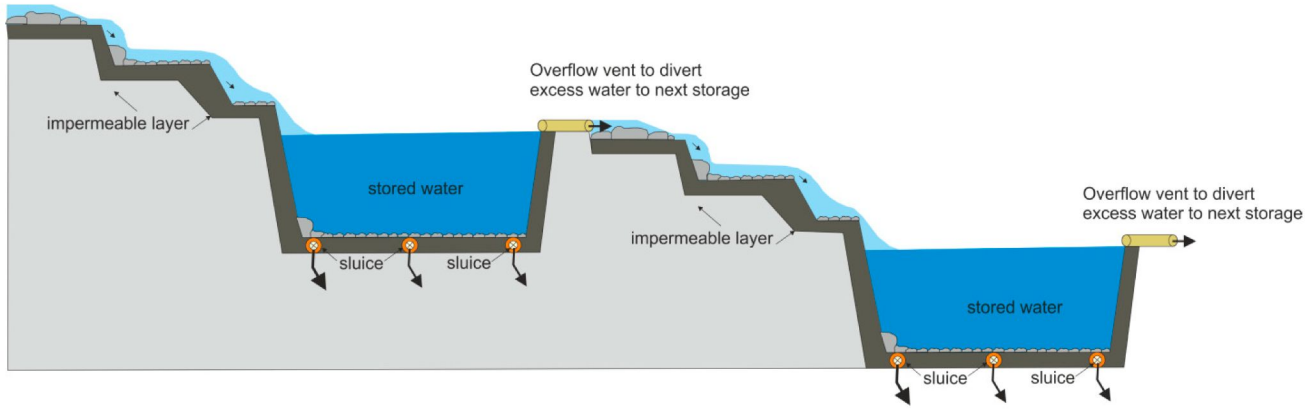
Sometimes **multiplayer** games with educational value

Science vs Learning

- Objective of a regular (full autonomous) agent simulations are to compare hypothesis
  - Advance the state of scientific knowledge in various domains
  - Especially certain investigation which is impractical or difficult to gather observations
- Objective of Participatory Simulation (*Games*) on the other hand
  - To educate (used in learning sciences)
  - To Inform (example: effects of political policies or land use etc)

Agent Based Modeling (IIITS efforts)

- Case Study of Rainwater Harvesting in Indian Villages - Kolagani et al 2015
- The proposed model is used to plan new RWH systems in this region and similar regions elsewhere
- They used ‘Participatory Simulation’ to work with farmers in the villages surrounding Tirupati



Kolagani, N., Ramu, P., & Varghese, K. (2015). Participatory model calibration for improving resource management systems: case study of rainwater harvesting in an Indian Village. *JAWRA Journal of the American Water Resources Association*, *51*(6), 1708-1721.

History of Participatory simulation

- “The Beer game” James Forester (inventor of systems dynamics) and his group at MIT in 1960s.
- The game highlights the ways in which costly unintended behaviors of a system
- There are recent participatory simulation with interesting results (Resnick & Wilensky, 1993; 1998; Wilensky & Resnick, 1995)
    - People play the role of ants in anthill

What is the (root) beer game?

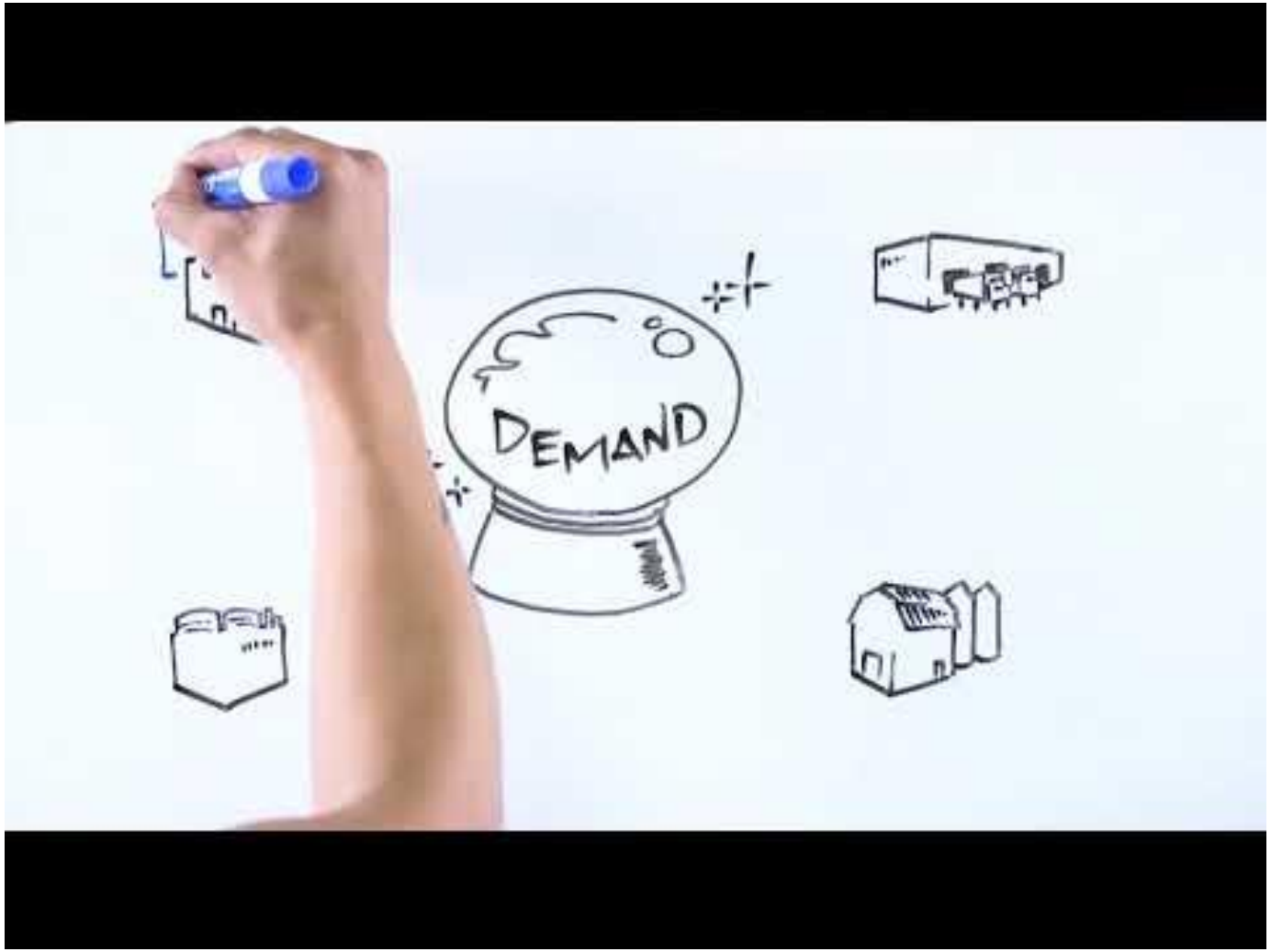
- Role playing simulation widely used in supply-chain management and systems dynamics classes
- 1956 GE observed huge swings in production levels completely disconnected with consumer demands
- Objective
  - How single parts in System influence each other
  - How individual thinking differs from Network/Collective thinking
  - How current behavior is not necessarily a predictor of future behavior/demand

Beer game for understanding Supply chains

Beer game practice

https://supplychain-academy.net/beer-game/

Bullwhip effect! (aka Forrester effect)



Examples of Bullwhip effect during COVID-19

- Masks
- Sanitizers
- Toilet-papers (in western countries)
- Even Canned Food items

Participatory Simulation - Challenges

- A potential barrier to widespread adoption of networked activities is the difficulties in authoring new PSA.
- Java-based development effort of N-Logo extends the object-based modeling capabilities of StarLogo to create a networked system supporting Participatory Simulation.
- Introducing HubNet! - The participatory simulation support in NetLogo

HubNet

- HubNet is new architecture to give students the experience of participating as elements in a simulation of a complex dynamic system.
- HubNet is an open client-server architecture, which enables many users at the "Nodes"
  - to control the behavior of individual objects or agents
  - to view the aggregated results on a central computer known as the "Hub".
- This network of nodes is integrated with a powerful suite of modeling, analysis and display tools.

Let's dive into HubNet examples!

Multi-Level Agent Based Modeling

Abstractions of Modeling

- Micro - Individual or Agent level modeling. Also called up Bottom-up modeling as we are trying to understand the dynamics of a complex system, by hypothesizing behavior of individuals/agent
- Macro - Global, Aggregate level simulation. Models built based on aggregates and factors influencing the aggregates and changes (Stocks and Flows as in System Dynamics)

Hybrid Modeling

- Sometimes it makes sense to approach a phenomenon by modeling it in multiple levels of abstraction
- This allows for greater control and better explainability
- Introducing ML – ABM Multi-level Agent based modeling

Multi-Level Agent Based Modeling

- ML – ABM Multi-level Agent based modeling
- Breaking up large, interrelated, complex systems into smaller, manageable models
- Imagine multiple agent based models inform each other
- Very interesting way to simulate macro and micro level modeling
- Example: Imagine that we are modeling a supply chain
    - Each model could represent a city/town or a single factory, while the root model could be the entire supply chain

Example: Simplified Climate Change Model

- Model of energy flow in the earth, particularly heat energy
- You can Control
  - Clouds
  - Amount of sunlight absorbed vs reflected (Albedo)
  - Amount of Carbon dioxide
  - Amount of Clouds
- A simplified model for understanding the effects of greenhouse gases in the atmosphere
- Mostly for educational purposes only!

Example: Predator Prey Model

- The interesting part is the version with Grass regrowth
  - In Real world, we know that the climate change affects plants and animals
  - There has been evidence that climate change affects how tall plant grows including grass
  - Wouldn’t it be nice if we can combine both the climate change model with the predator prey model.
    - Yes! the Netlogo extension LevelSpace Allows us to do that

Level Space

- A popular extension to NetLogo library
- LevelSpace is NetLogo's way for supporting ML – ABM Multi-level Agent based modeling
- Lets see the example for combining Climate Change and Predator Prey Model and also a few more examples

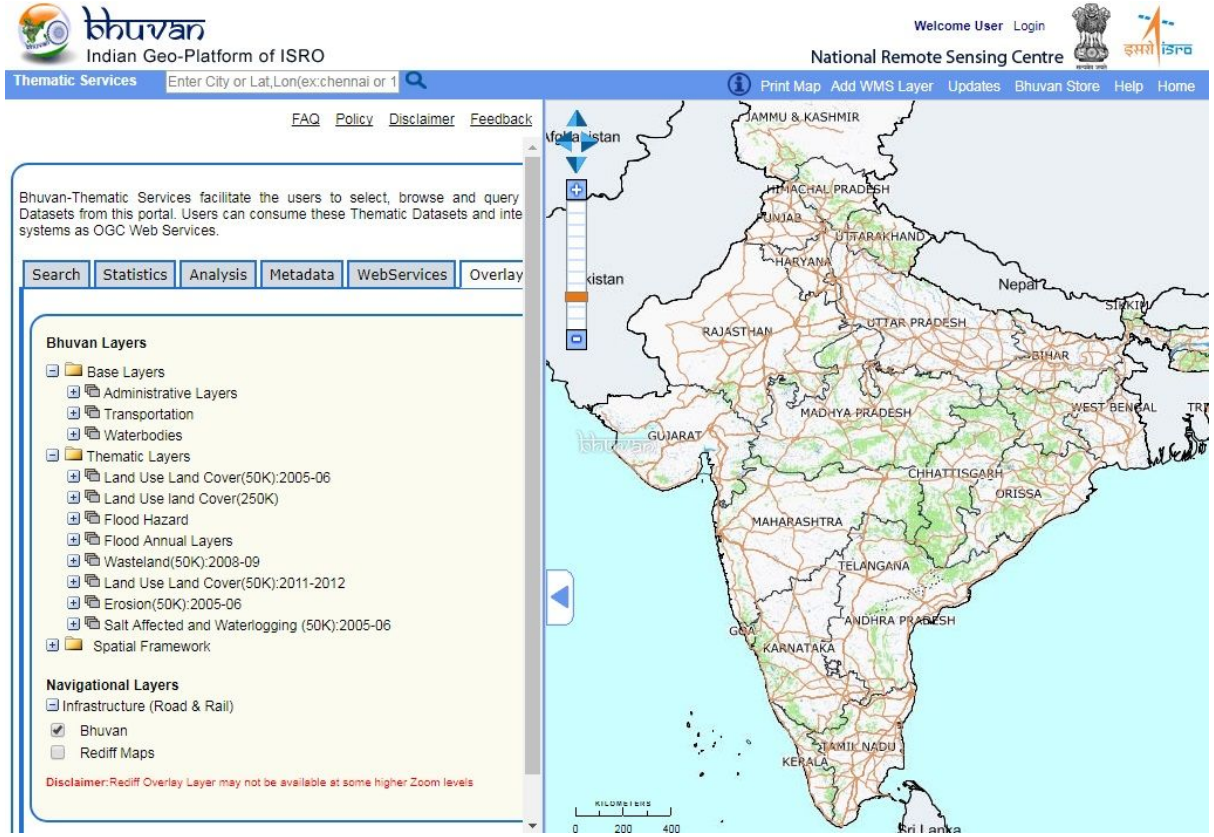
Level Space examples!

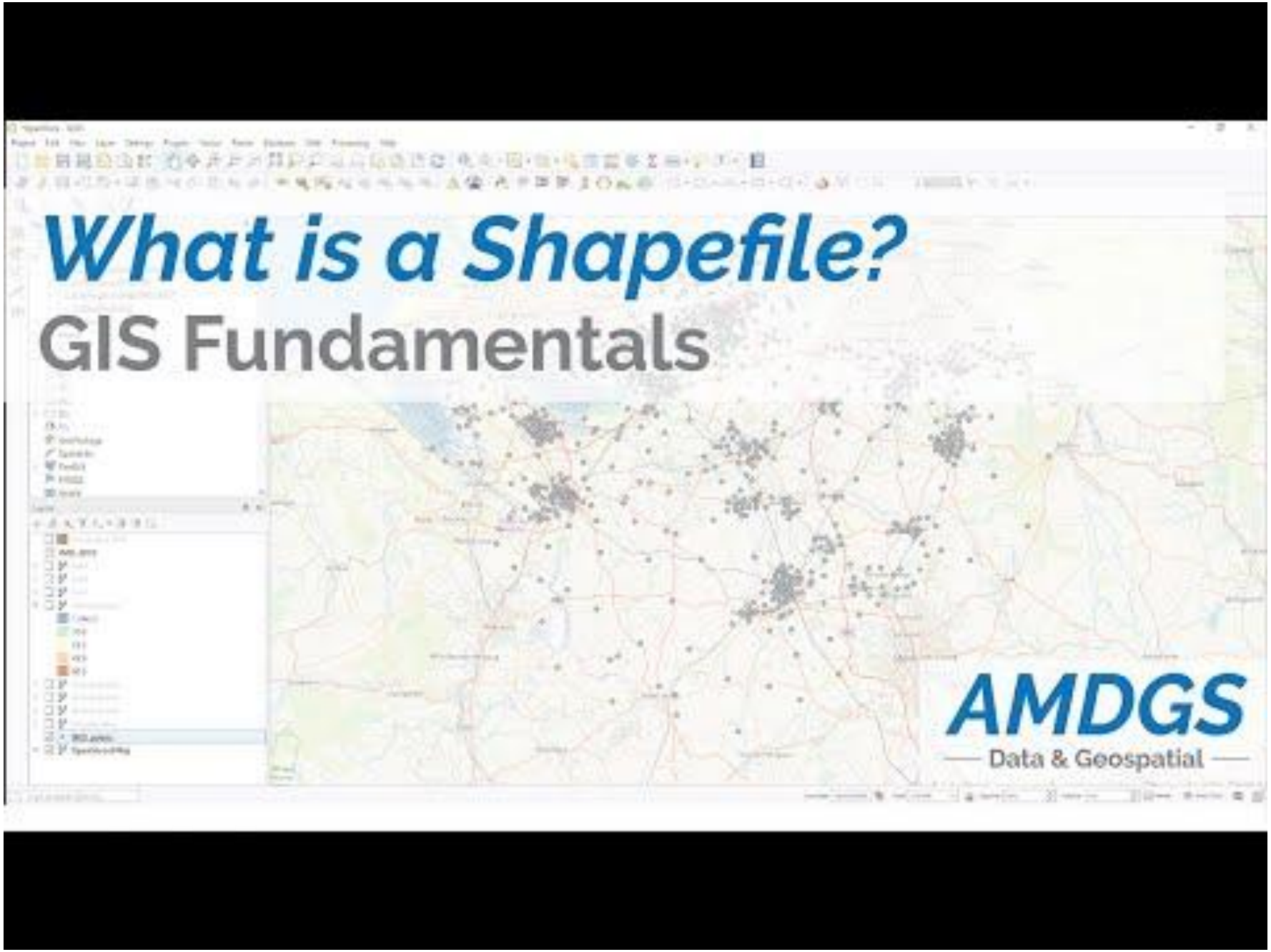
GIS - Geographic Information Systems

- Area of research and framework for handling data associated spatially with the earth’s geography.
- GIS enables maps that communicate information
- Perform analysis, share information and solve complex problems
- There are a set of standards followed for GIS

Shape File

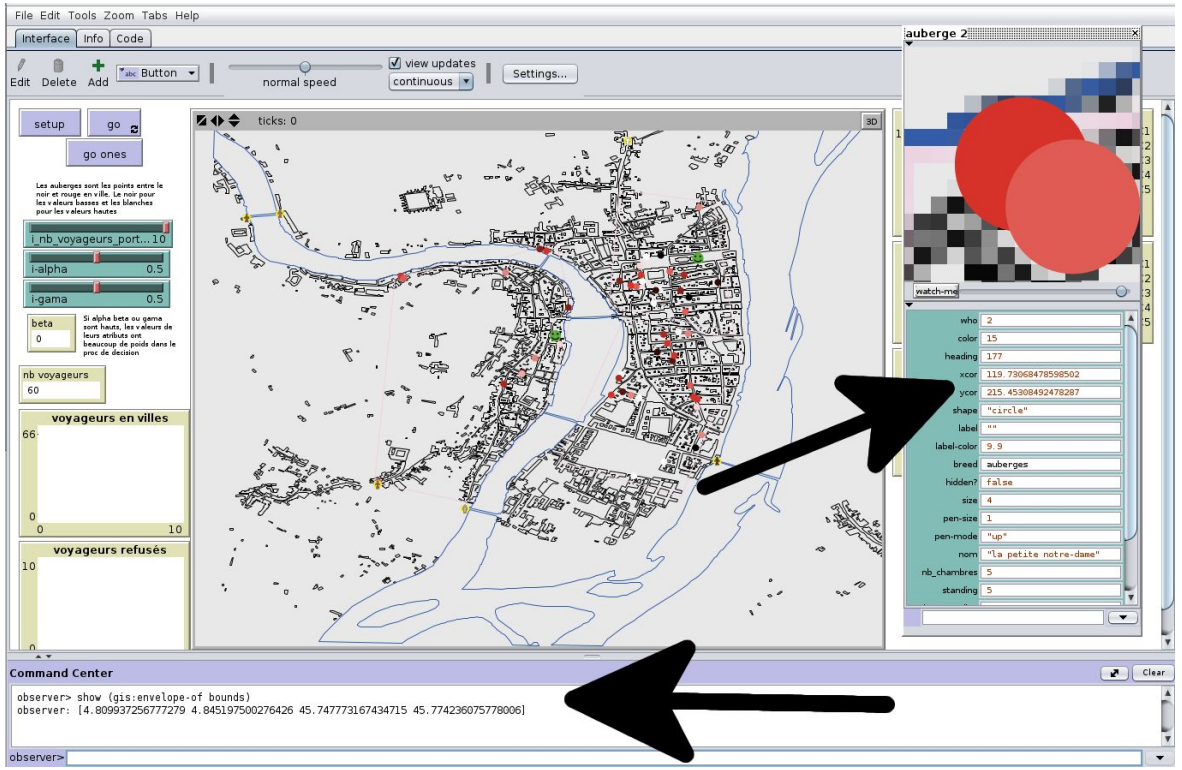
- Vector data (Point, Line & Polygons) and Feature Data
- Multiple files that work together (Not a Single file)
- Software like ArcGIS/QGIS enables working with shape files easy




What is a Shapefile?
GIS Fundamentals
AMDGS
Data & Geospatial

NetLogo GIS Extension

- Allows you to work with Shape Files and GeoJSON file
- You use union of Shape File envelopes to mix information and can run simulations



NetLogo GIS Extension

- Lets see some examples!