

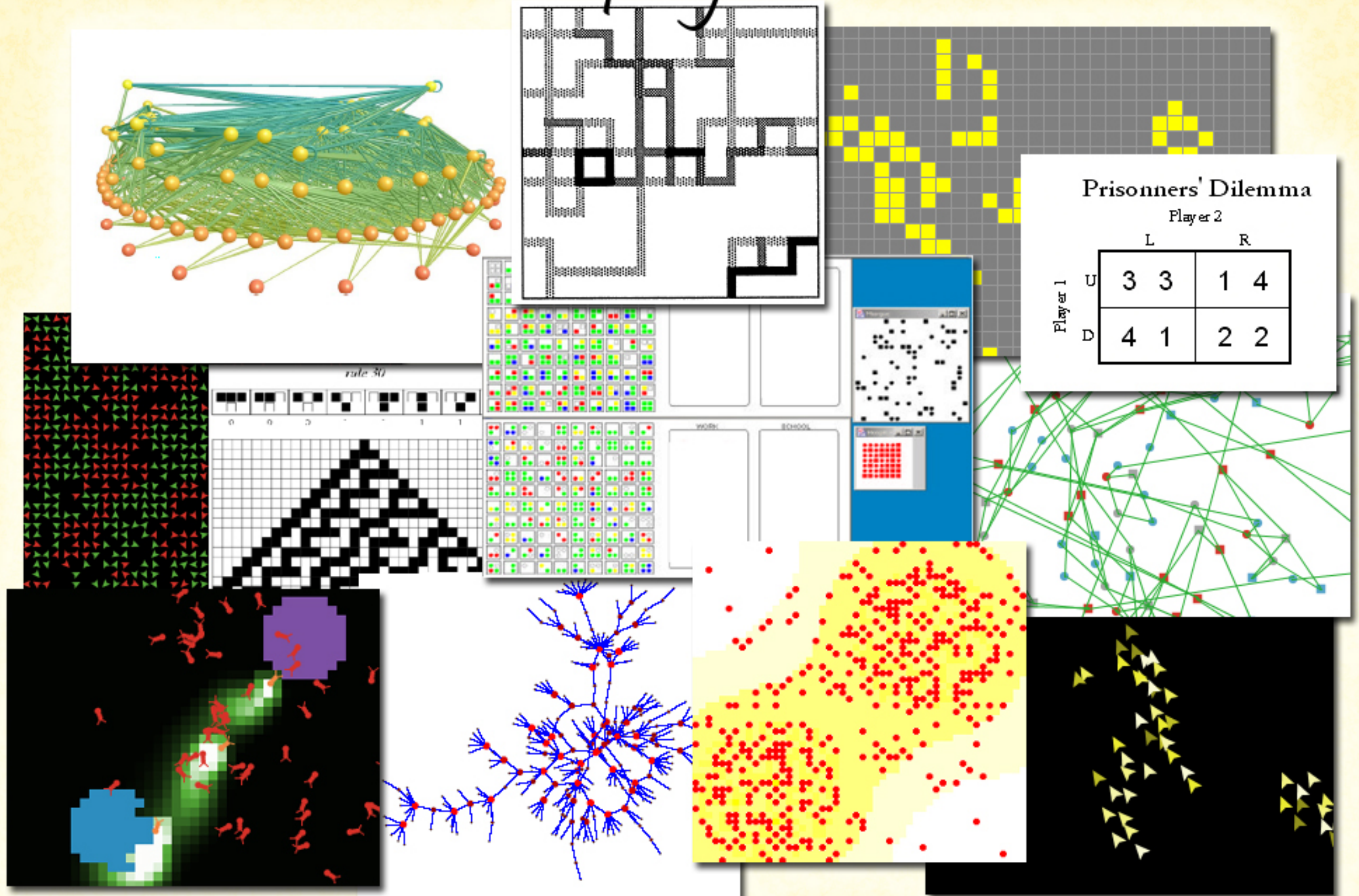
Introduction to Agent-Based Modeling for Social Scientists **DAY 2**

with your host:

Charles Dorian

INTRODUCTION TO AGENT-BASED MODELING

Various Flavors of Agent-Based Models



Is an Agent-Based Model What You Need?

What Characteristics of the Behavior are Essential?

- Perspective A: use Occam's Razor - simplest model possible
- Perspective 1: use Kitchen Sink - put in everything
- Complex Systems Exhibit Opaque Attribute Contexts

Which Modelling Techniques(s) Can Capture Them

- Differential Equation Model: dynamic behavior with equilibria
- Statistical Model: predicting behavior through historical analysis
- Analytical Models: equation based with closed form solutions
- Real-World Experiments: scaled-down replica of actual system
- Agent-Based Models: open-ended rule-based computer simulations

Who Will Use the Model and for What?

- Personal Experimentation vs Student Pedagogy
- Prediction, Exploration, Explanation, and/or Existence Proof

What are your Skill/Time Restrictions?

Is an Agent-Based Model What You Need?

Benefits

- Implicit NonLinear Dynamics (Feedback & Dynamic Interactions)
- Spatially Explicit
- Heterogeneous and Adaptable Agents
- “Medium” Number of Agents
- Adaptable/Evolvable System Characteristics
- Exponential Increases in Computer Power
- Plagiarism is Encouraged and Rewarded
- Visualization Can Pump Intuitions and Impress Others

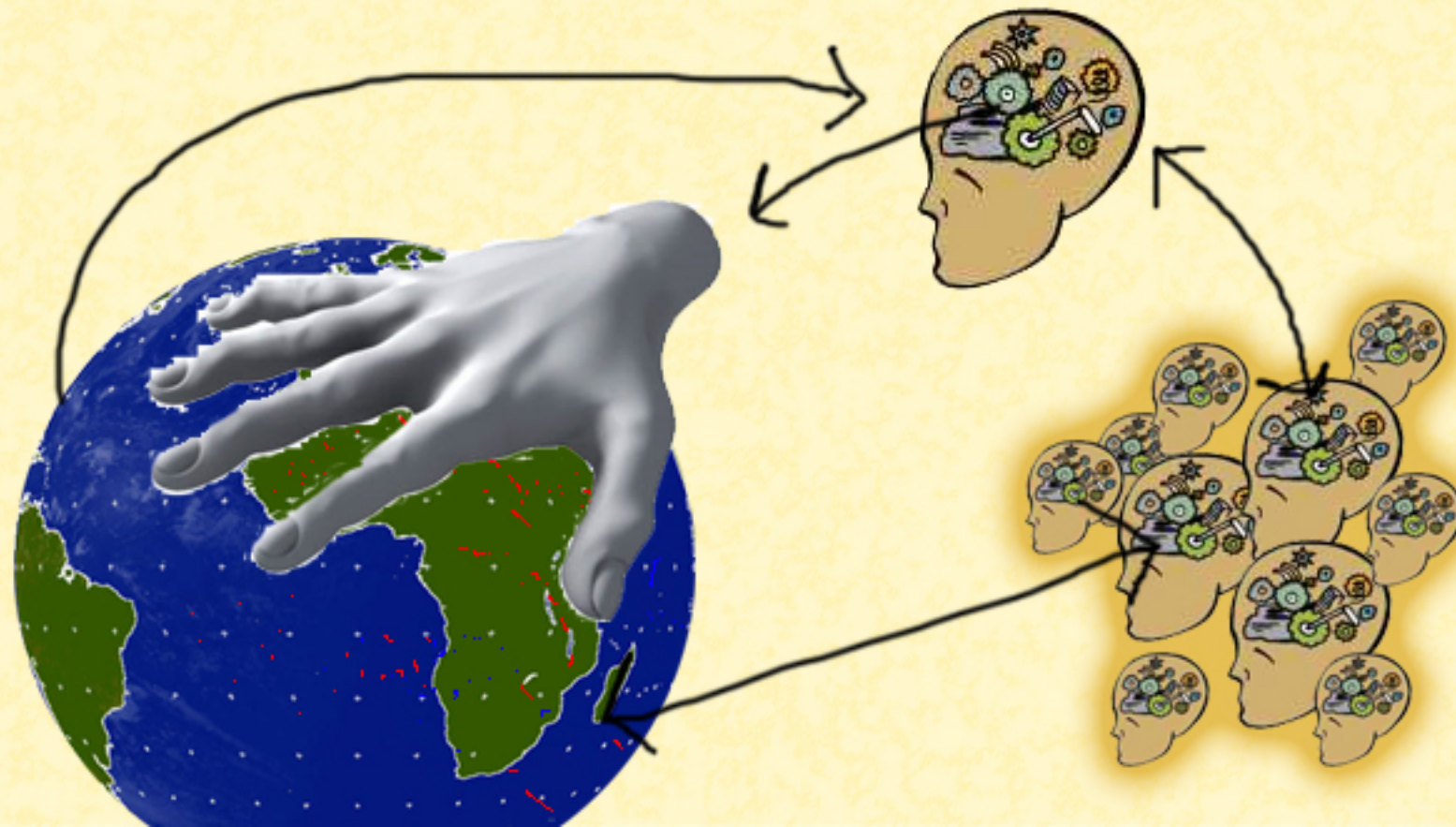
Limitations

- Difficult to Analyze Results and Causal Mechanisms
- Social Stigma Against ABMs
- Practical Limits of Computing Power
- Requires some Computer Programming Ability

Components of Agent-Based Models

Agents

- Rule-Based Behavior (Possibly Learning & Adapting)
- Interact with the World and Each Other
- Between Two and One Duotrigintillion Agents

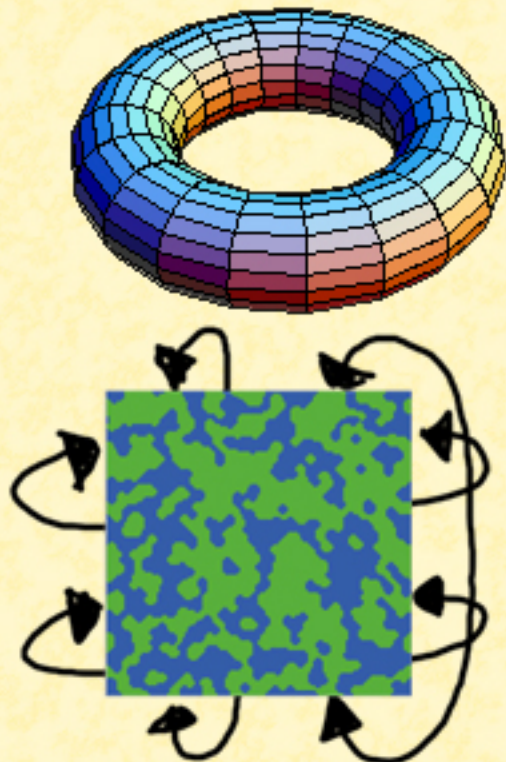


Components of Agent-Based Models

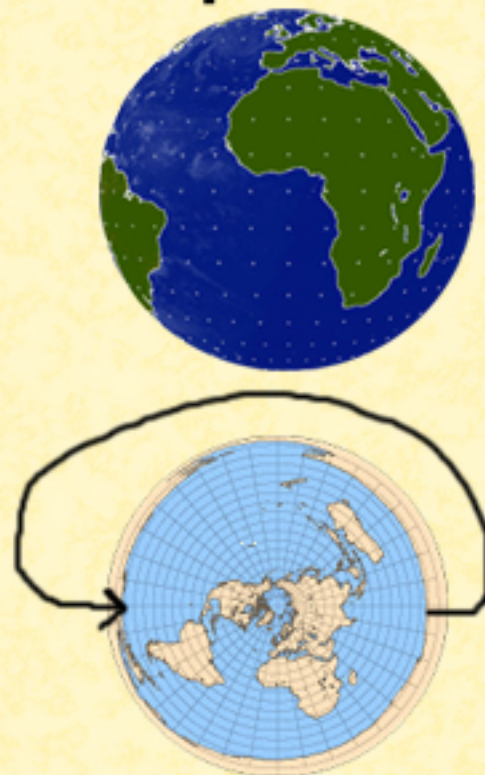
World

- Pick Your Dimensions: zero through infinity
- Bounded vs Wrapped (Rings and Toroids)
- Holds Values (Environment) which May Be Dynamic
- Divided into Discrete Space or Not

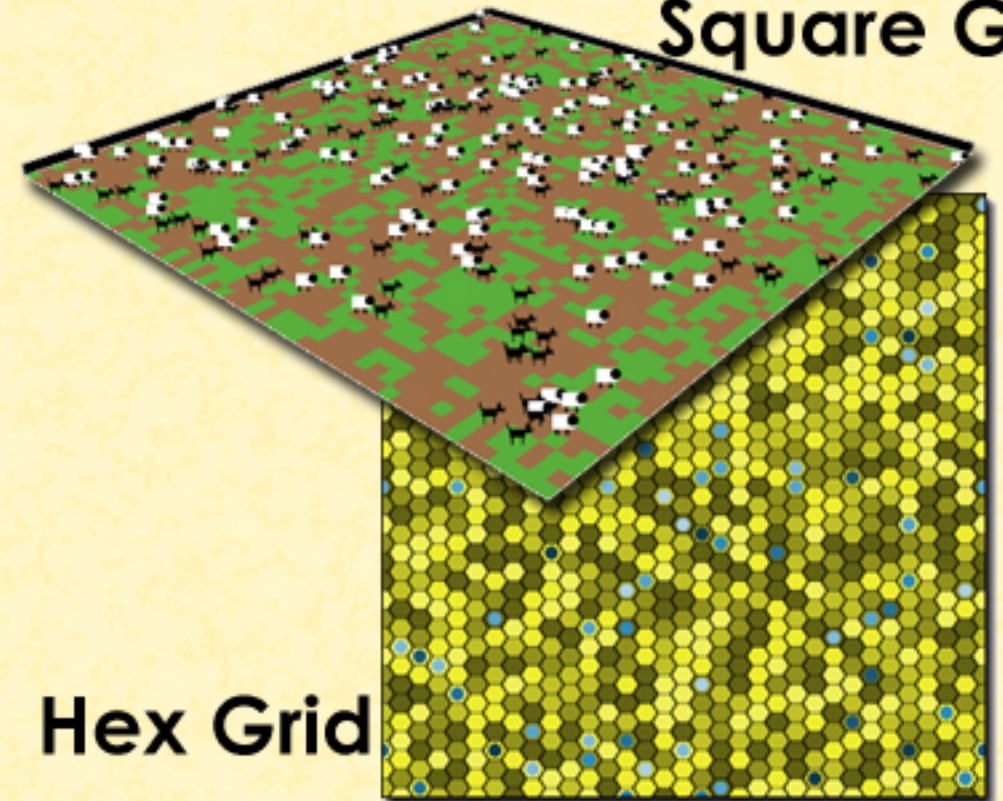
Torus



Sphere



Square Grid



Hex Grid

Components of Agent-Based Models

Scheduler

- Determines Order of Execution of Events
- Discrete Time Steps vs Event-Driven Updates
- Synchronous vs Sequential AKA Parallel vs Serial
- How Does the Model Know When It's Done

		P1A		P1B		P1C		P2A		P2B		P2C		P3A		P3B	
		22 17 May 8 Jun		23 8 Jun 1 Jul		26 2 Jul 28 Jul		21 28 Jul 18 Aug		18 19 Aug 6 Sep		28 6 Sep 4 Oct		14 5 Oct 19 Oct		27 19 Oct 15 Nov	
T1-X5	Setup 7	CMS CSC 9	CMS CSC 13	CMS CSC 7	ALICE HMPID 5	ALICE Muon 12	ALICE HMPID 19	NA62 9	ALICE SDD 29		4	CMS-Tracker 32		ALICE HMPID 9	5	TOTEM 12	
T1-GIF	Setup 7	ATLAS RPC 9	CMS RPC 19	ALICE RPC 17		LHCb MWPC 17	ATLAS CSC 18	ATLAS MDT 20	CMS RPC 12	ALICE TOF 15	7	ATLAS RPC 11	8	ATLAS RPC 9	5	ALICE RPC 12	
T1-X7	Setup 7	CMS 9	LHCb HCAL 7	LHCb HCAL 6	LHCb VELO 7	LHCb ST 10	RD42 7	LHCb HCAL 4	LHCb HCAL 7	LHCb HCAL 6	LHCb HCAL 10	LHCb HCAL 8	RD42 7	CMS PS 7	LHCb HCAL 5	LHCb VELO 3	LHCb VELO 12
T2-H2	Setup 7	CMS HBHE 22		CMS HBHE 7	CMS HF 10	CMS HBHE 7	CMS HF 28	CMS HBHE 7	CMS Pixel 11	CMS Pixel 7	8	7	7	CMS HCAL 5	CMS HBHE 13	CMS HBHE 9	CMS HBHE 8
T2-H4	Setup 7	DREAM 11	CMS ECAL 11	CMS ECAL 7	CMS ECAL 10	CHUDAKOV 14	DREAM 1	LHCb 12	18	CMS ECAL 7	20	7	13	CMS ECAL 7	CMS ECAL 13	26	CMS ECAL 8
T4-H5	Setup 7	ATLAS EMECHEC/FCAL 22		ATLAS EMECHEC/FCAL 2	ATLAS EMECHEC/FCAL 4	ATLAS EMECHEC/FCAL 10	NA60 Test 14	ALICE ZDC 14	SC RP 12	ATLAS-EMECHEC/FCAL 6				SC RP 3	ALICE ITS 19		
T4-H8	Setup 7	ATLAS 9	ATLAS Combined 13	ATLAS Combined 7	ATLAS Pixel 5	ATLAS Combined 12	ATLAS TRT 7	ATLAS Muon 12	ATLAS Combined 12	ATLAS Pixel 10	12		27	ATLAS Muon 14	ATLAS Combined 12		
T4-P0	Setup 7	NA62 22		NA62 7		NA62 52				NA60 45				NA60 6	NA60 4	NA60 26	
T6-M2	Setup 7	COMPASS 22		COMPASS 7				COMPASS 97								COMPASS 28	

Components of Agent-Based Models

Other Common Elements

- Resources, Obstacles, Landmarks as “Agents”
- GUI, Graphs, Reports, Documentation, ...

```
:: these patches are the "best land"
ask patches
[ set max-grain-here 0
  if (random-float 100.0) <= percent-best-land
    [ set max-grain-here max-grain
      set grain-here max-grain-here ] ]
:: spread that grain around the window a little and put a little back
:: into the patches that are the "best land" found above
repeat 5
[ ask patches with [max-grain-here != 0]
  [ set grain-here max-grain-here ]
  diffuse grain-here 0.25 ]
repeat 10
[ diffuse grain-here 0.25 ]
ask patches
[ set grain-here floor grain-here :: spread the grain around some more
  set max-grain-here grain-here :: round grain levels to whole numbers
  recorder-patch ]
end
to recolor-patch :: patch procedure -- use color to indicate grain level
set pcolor scale-color yellow grain-here 0 max-grain
end
:: set up the initial values for the turtle variables
to setup-turtles
set-default-shape turtles "person"
no-display :: so we don't see the turtles until they're recolored
cvt max-people
[ setxy (random screen-size-x)
  (random screen-size-y)
  set size 1.5 :: easier to see
  set-initial-turtle-vars
  set age random life-expectancy ]
recolor-turtles
display
```

Class Plot

Pens

low
mid
up

Class Histogram

Pens

Lorenz C

Time

Pens



What are Agents Based Models Made of?

Space and Movement

- Space Measure (e.g. Distance) in 1D, 2D, or absent?
- Exogenous vs Endogenous Movers (Preferences vs Wind)

Complicated Agents

- CAs and Pure Networks Limit Agent Abilities
- Learning vs Adapting vs Evolving
- Agents using AI and internal models

Model Dynamics

- Agent Birth and Death
- Agents Exchanging Resources and Information
- Agent-Environment Feedback

What are Agents Based Models Made of?

User-Defined

- Set by users during setup or dynamically
- Initial Conditions or Boundaries
- Takes a Range of Values (Sweepable)
- Define Range and Granularity

“Tweaked”

- Hidden Parameters (Hard-Coded)
- Set at Values that are Known to “Work”

Distributions

- Select Type of Distribution (Normal, Exp,...)
- Select Distribution Parameters

Everything Must Be Decided

BY YOU!

