CNI 세미나 2019-076

연구정책조성 세미나

- 행위자기반 모델링을 위한 CyberGIS-Jupyter 활용 -

주최·주관 : 충남연구원 공간·환경연구실

일시 : 2019년 8월 14일(수) 10:00

장소 : 충남연구원 4층 세미나실

진행순서

10:00~10:10 개회 및 참석자 소개 (사회 : 김형철 책임연구원)

10:10~11:10 주제 발표

Dr. Jeon-Young Kang (University of Illinois at Urbana Champaign)
"Reproducible CyberGIS-Jupyter Framework for Spatially Explicit Agent-Based Modeling"

11:10~11:50 토론 (좌장: 김원철 연구위원)

조종석 센터장 (한국교통연구원 국가교통DB센터)
최재성 책임연구원 (국토연구원 국토인프라연구본부)
오상진 선임연구위원 (충북연구원 공간창조연구부)
오용준 실장 (충남연구원 공간·환경연구실)
사공정희 책임연구원 (충남연구원 공간·환경연구실)
명형남 책임연구원 (충남연구원 공간·환경연구실)
김형철 책임연구원 (충남연구원 공간·환경연구실)
최돈정 책임연구원 (충남연구원 공간·환경연구실)

11:50~12:00 폐회 및 정리

Reproducible CyberGIS-Jupyter Framework for Spatially Explicit Agent-Based Modeling

Jeon-Young Kang (강전영)

CyberGIS Center for Advanced Digital and Spatial Studies
CyberInfrastructure and Geospatial Information Laboratory
Department of Geography and Geographic Information Science
University of Illinois at Urbana-Champaign

ChungNam Institute

August 14, 2019

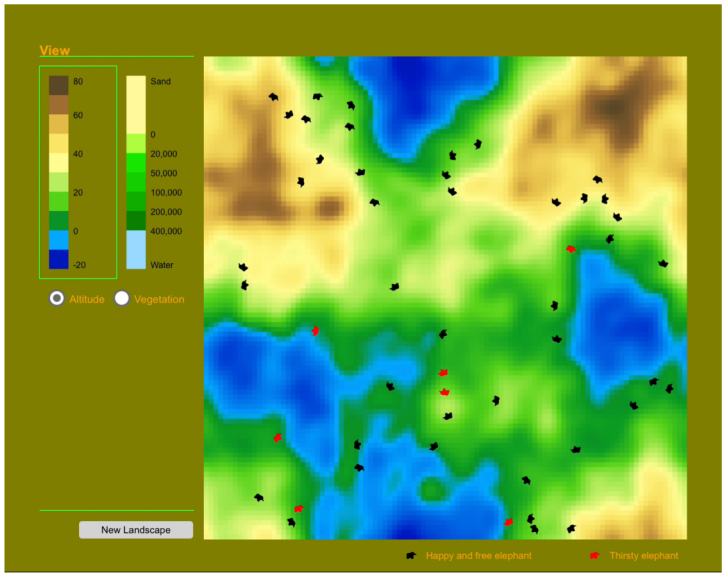
Overview

- Agent-based modeling (ABM)
- CyberGIS
- Jupyter Notebook
- Reproducibility & Replicability (R & R)
- R & R in ABMs

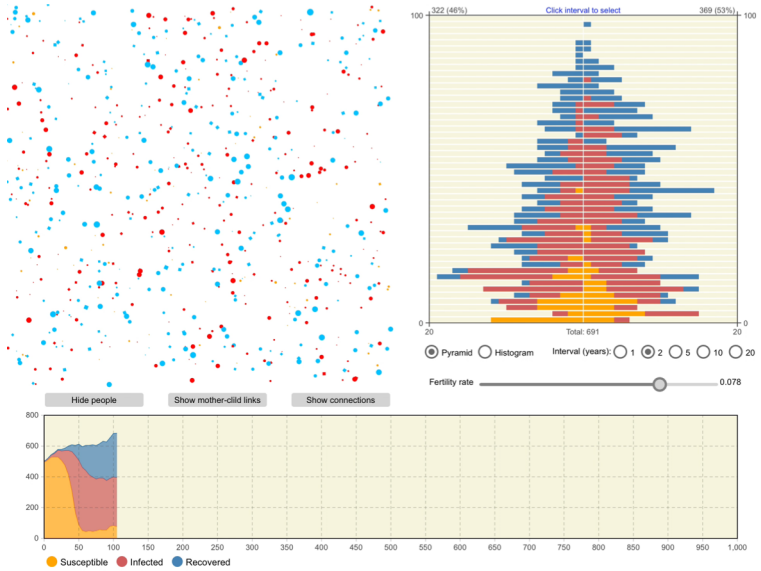
Agent-Based Modeling (ABM)

- Capture and simulate various spatiotemporal phenomena
  - Dynamic interactions between heterogeneous agents and their spatially explicit environment
- Used in hypothesis testing, policy analysis, etc.

Ecology

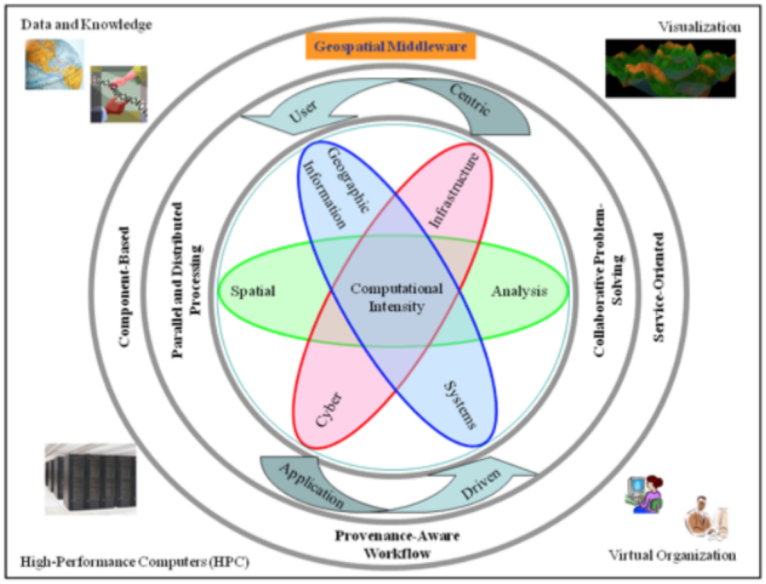


Health



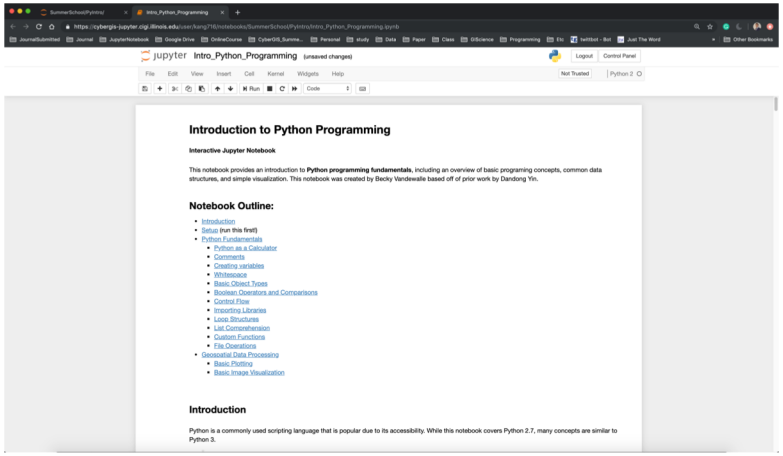
CyberGIS

- Definition
  - Geographic Information Science and System (GIS) based on advanced computing and cyberinfrastructure
- Purpose
  - Focuses on computational and data-intensive geospatial problem-solving within various research and education domains
  - Bridge gaps between geospatial big data, software and applications through advanced cyberinfrastructure



Wang, S. (2010) A CyberGIS Framework for the Synthesis of Cyberinfrastructure, GIS, and Spatial Analysis, *Annals of the Association of American Geographers*, 100(3): 535-557

The Jupyter Notebook



The Jupyter Notebook is an open-source web application that supports to share documents, code, equations, visualization, and narrative text.

- Uses: data cleaning, transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more

Source: https://jupyter.org/

CyberGIS-Jupyter

"An innovative cyberGIS framework for **achieving data-intensive, reproducible, and scalable geospatial analytics using Jupyter Notebook based on ROGER**, the first cyberGIS supercomputer"

Be capable to accelerate gateway application development and sharing while **associated data, analytics, and workflow runtime environments are encapsulated in to packages** that can be elastically reproduced through cloud-computing approach

Yin, D., Liu, Y., Hu, H., Terstriep, J., Hong, X., Padmanabhan, A., & Wang, S. (2019). CyberGIS-Jupyter for reproducible and scalable geospatial analytics. *Concurrency and Computation: Practice and Experience*, *31*(11), e5040.

Reproducibility & Replicability

- Reproducibility (재생/재현)
  - Reproducibility is to obtain consistent results using the same input data, computational steps, methods, and code, and condition of analysis.
  - Synonymous with computational reproducibility

- Replicability (복제)
  - Replicability is to obtain consistent results across studies aimed at answering the same scientific questions, each of which has obtained its own data.
  - Two studies may be considered to have replicated if they obtain consistent results given the level of uncertainty inherent in the system under study.

National Academies of Sciences (2019). Reproducibility and replicability in science.

Overview, Design Concept, and Details (ODD)

Grimm, V., Berger, U., Bastiansen, F., Eliassen, S., Ginot, V., Giske, J., ... & Huth, A. (2006). **A standard protocol for describing individual-based and agent-based models**. *Ecological modelling*, *198*(1-2), 115-126.

Table A1. Overview, design concepts and details of ABMs.

Overview	
Purpose	To simulate a local-level DENV transmission with eight scenarios: (1) HeteroRealPre, (2) HeteroRealReset, (3) HeteroSynthPre, (4) HeteroSynthReset, (5) HomoRealPre, (6) HomoRealReset, (7) HomoSynthPre, and (8) HomoSynthReset
Entities, state variables, and scales	ABM consists of three entities: (1) human, (2) infectious female mosquito, and (3) building agents, and each entity has several state variables. (1) Human agent • Age • Gender • Occupation status • House location: x-y coordinates • School/workplace location: x-y coordinates • Current location: x-y coordinates • SEIR states for all DENV serotypes • Cross immunity state (2) Mosquito agent • Age • Serotype (3) Building agent • Type • Location: x-y coordinates
Process overview and scheduling	(1) Movement •Human: commuting process: school (aged 5–19) and workplace (aged 20–64) •Mosquito: moving around within 30 m (15 % of probability) and random locations (1% of probability) (2) The birth, death/out-migration and aging •January 1st every year, the certain amounts of individual humans are newly born and died/out-migrated. The newly born humans are randomly assigned to houses. •January 1st every year, every individual gets older. The property (age) increases by one. (3) scheduling for immunity •In reset scenarios, the immunity status of an individual is reset and assigned based on individual's age. (4) Biting •Mosquitoes bite humans with a certain probability (5) Seasonal fluctuation of mosquito population •The counts of mosquito population vary to month as shown in Figure 6.
Design concepts	
Basic principles	The ABMs purpose to explore the impacts of model specifications in regard to (1) spatial configurations of buildings, (2) spatial distribution of mosquito population, and (3) immunity status of individual human. The model was expanded based on Chapter 4.
Sensing	Each mosquito senses the neighboring houses to move around and human to bite in all buildings.
Interaction	There is an interaction between humans and mosquitoes by biting process of mosquitoes.
Details	

(*Continued*)

Not enough for Replicable & Reproducible ABMs

Kang, J. Y., & Aldstadt, J. (2019). Using multiple scale spatio-temporal patterns for validating spatially explicit agent-based models. *International Journal of Geographical Information Science*, *33*(1), 193-213.

Reproducible Spatially Explicit ABMs

- Purpose
  - To achieve data-intensive, reproducible ABMs using Jupyter Notebook
    - Provides a holistic solution
    - Makes sharing codes and workflows easy
  - To reduce the barrier to accessing the advanced cyberinfrastructure and cyberGIS capabilities
    - Exploit JupyterHub, cloud, and high-performance computing resources

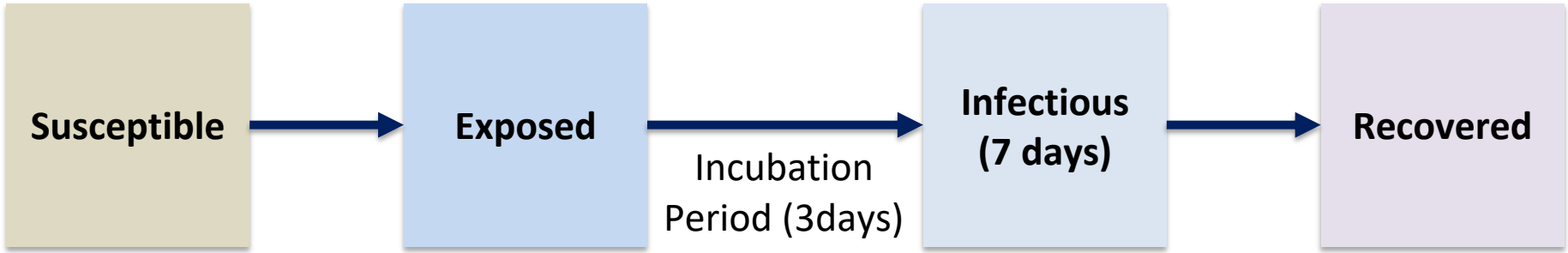
Influenza

- A contagious respiratory illness cased by influenza virus
  - Cause mild to severe illness
  - Serious outcome: hospitalization or death
- Some people (elders, young kids) at higher risk of serious flu complications

Source: https://www.cdc.gov/flu/about/index.html
shorturl.at/eiSU8
shorturl.at/gzAC0

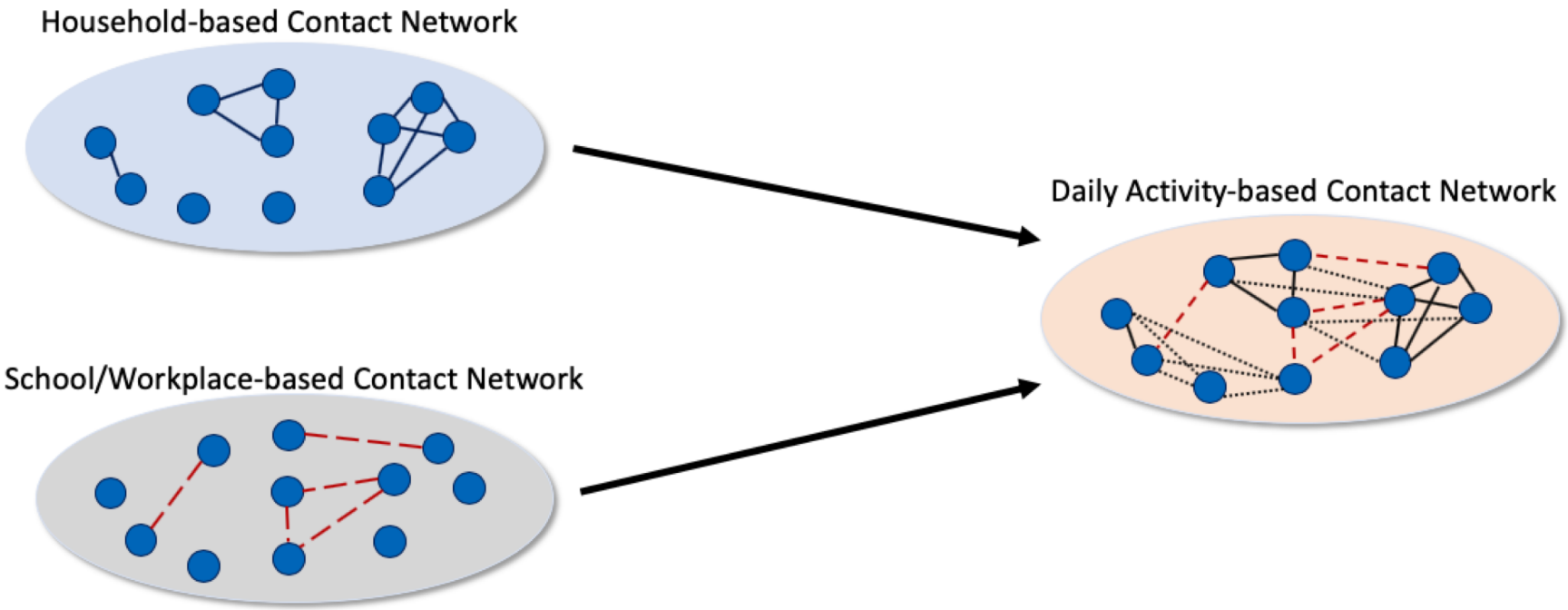
Agent-Based Modeling of Influenza

- Individual human agents
  - Age-dependent behaviors
    - Aged 6 to 19 : commuting to schools
    - Aged 20 to 64 : commuting to workplaces
  - SEIR status

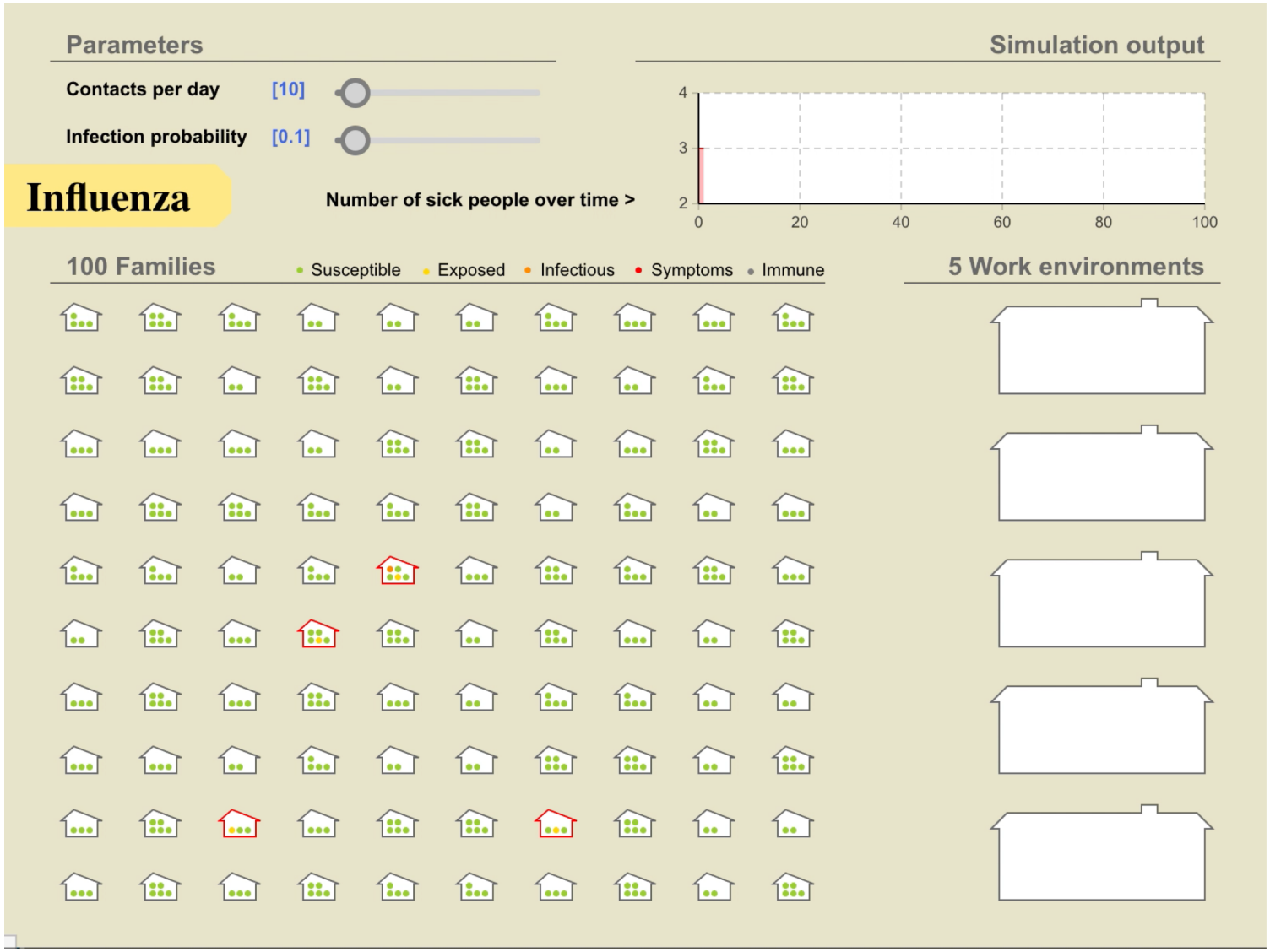


Contact Network

- Based on individual human agents' movement behaviors
  - Commuting to schools/workplaces

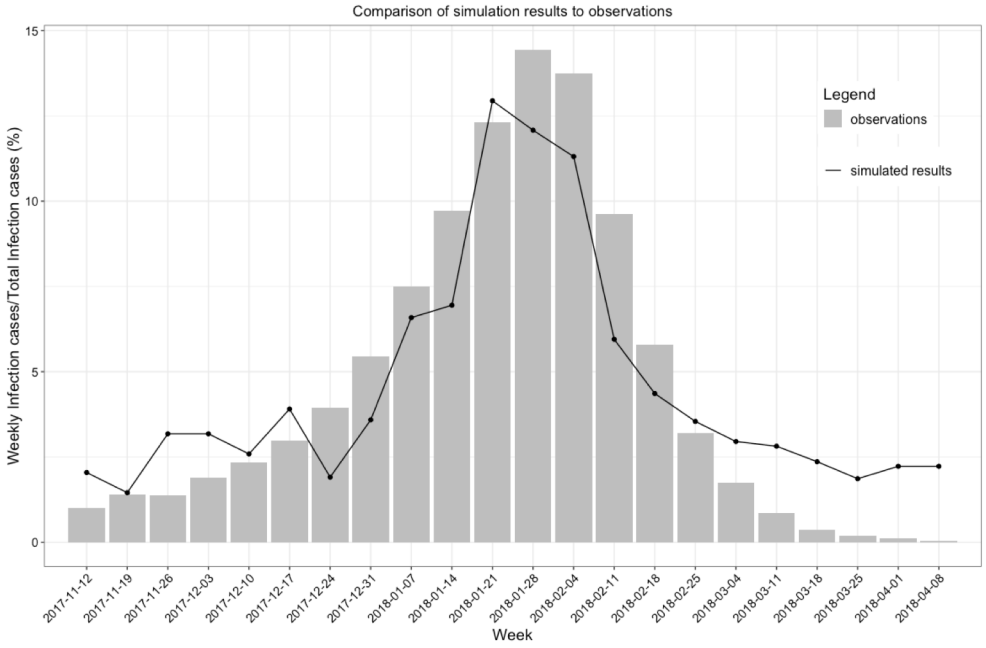


An example: ABM of Influenza



Source: AnyLogic Clould

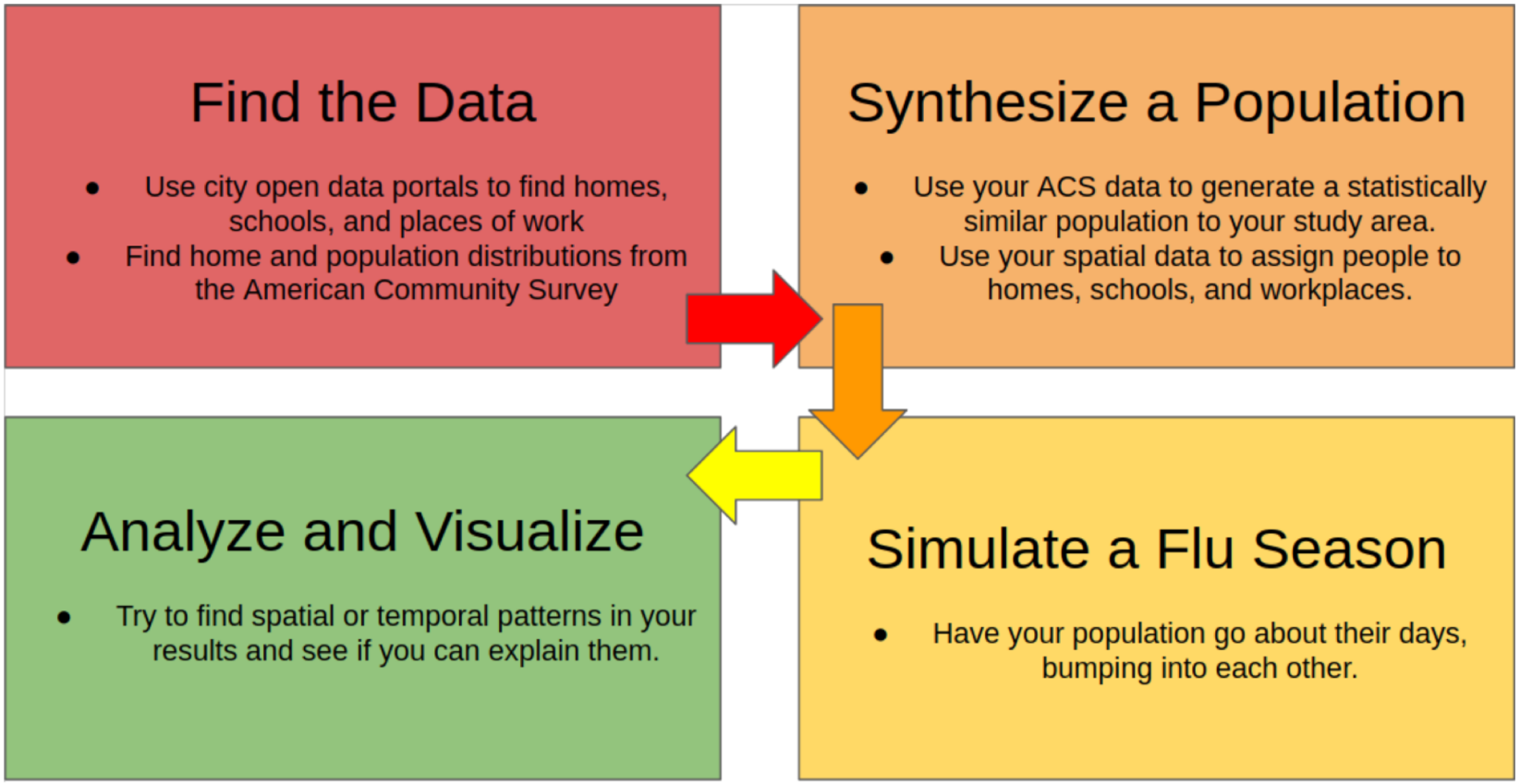
Simulation Outputs



Kang *et al.*, (in review) *An integrated framework of global sensitivity analysis and calibration for spatially explicit agent-based modeling*

Demo: CyberGIS-Jupyter for Influenza

Workflow



https://cybergis-jupyter.cigi.illinois.edu/user/kang716/notebooks/group_work/group5/KRIHS_talk.ipynb

ABMs for electric cars

- Policy Analysis
  - Government subsidies (for sustainable environment)
    - electric cars vs. charging station
  - Optimal allocation of charging station

Acknowledgments

- **National Science Foundation**
  - ACI-1443080
  - DEB-1824961
  - OAC-1743184

Thanks !

- **Comments / Questions?**
- **Email: geokang@illinois.edu**
- **Twitter : @jeonyoun**

토론

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질의응답

감사합니다!