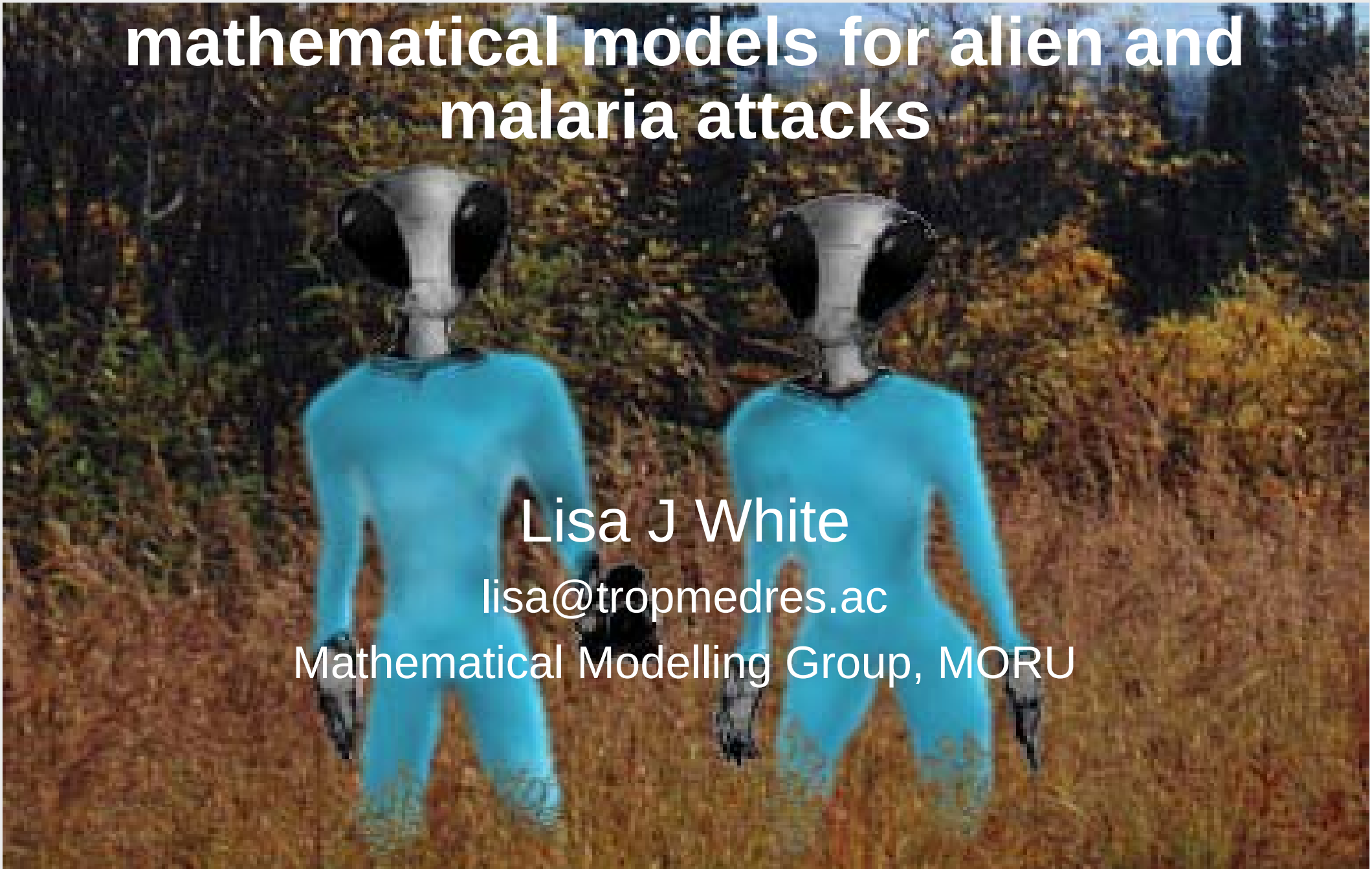
# Space the final frontier:

## mathematical models for alien and malaria attacks



Lisa J White

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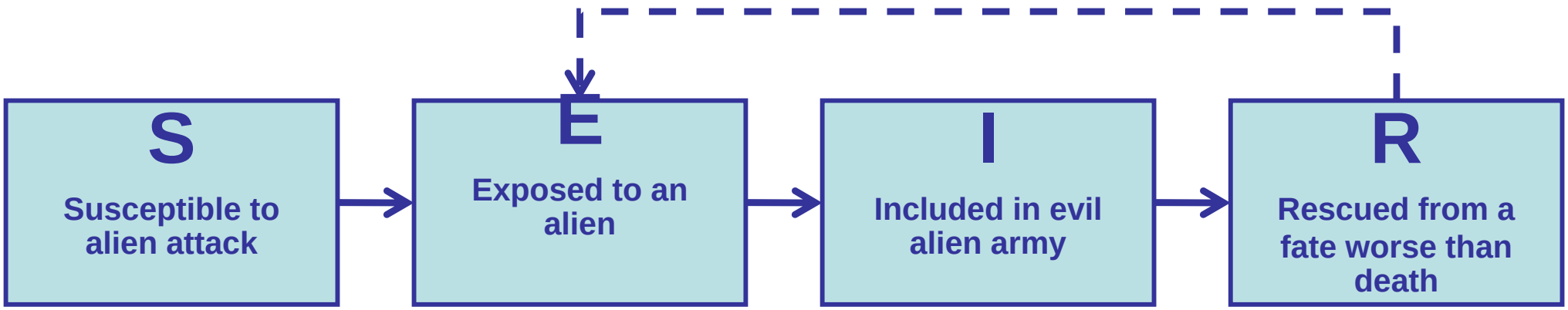
Mathematical Modelling Group, MORU

# The malaria modelling team at MORU

- Lisa White (head of mathematical modelling )
  - group of 9 members
- Wirichada Pongtovornpinyo (senior modeller)
  - population movement
- Richard Maude (MD and PhD student)
  - spread and containment of artemisinin resistance
- Sompob Saralamba (PhD student)
  - within-host PKPD malaria infection models

# Mind controlling aliens – the process




# What can we do? – surf the net of course!

- See http://io9.com/5103823/get-rid-of-your-mind+controlling-parasite-in-nine-easy-steps

- We will consider 3 options…..

# Remove It By Force

## (treatment)

Lexx “Eating Pattern” and “Bad Carrot”: Lexx features a pair of mind-controlling parasites. The snake-like creature in “Eating Pattern” turns Stan into a cannibal and has to be forcibly extracted from his neck. The carrot-shaped drone in “Bad Carrot” enters through the rectum and must be expelled the same way.

# Build Up Your Post-Infection Immunity

## (partial immunity)

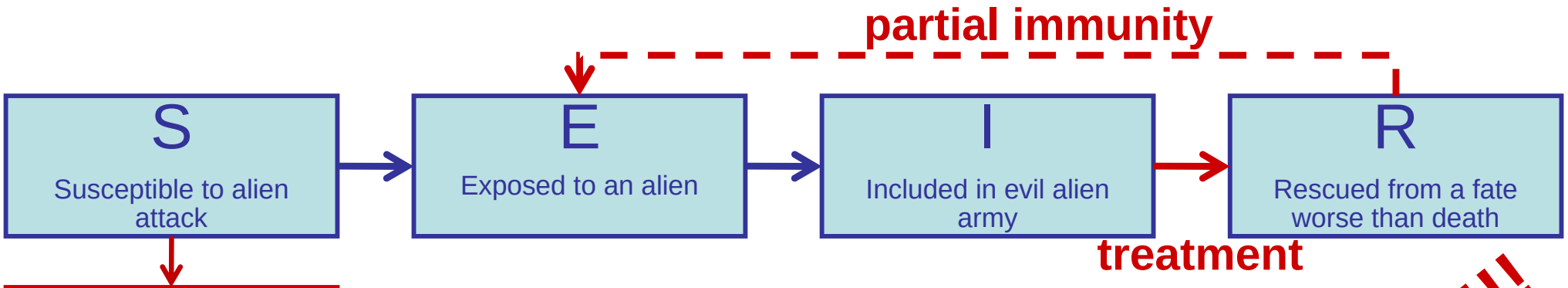
*The X-Files:* Purity, the fearsome Black Oil that appears throughout the series, is absorbed by humans on contact. The human host becomes a slave to the alien Black Oil, spreading the virus to others and helping the extraterrestrial colonists reproduce. There is a vaccine, albeit a weak one, which has, in some cases, reversed the infection.

# Switch to a Garlic Shampoo

# (vaccination)

Futurama: Switching to a garlic shampoo deters attachment, **as does wearing a helmet**. Just be sure that you don't mistake a fallen brain slug for an unusual hat, or you could be reinfected before you get a chance to wash your hair.

# When Aliens Attack Bangkok!!!!



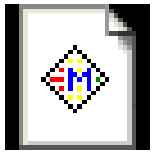

$$S' = -\frac{aIS}{N} - hS$$

$$E' = \frac{aIS}{N} + \frac{abIR}{N} - cE$$

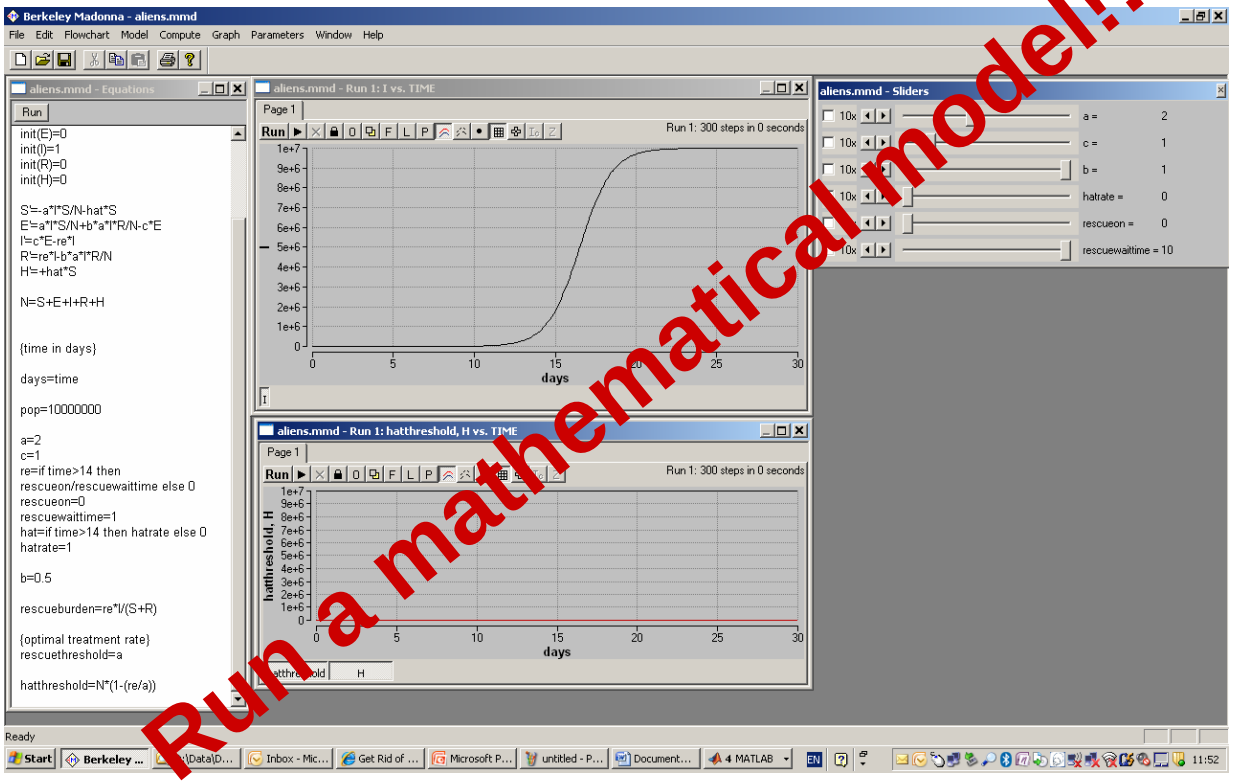
$$I' = cE - rI$$

$$R' = rI - \frac{abIR}{N}$$

$$H' = hS$$



Aliens.mmd





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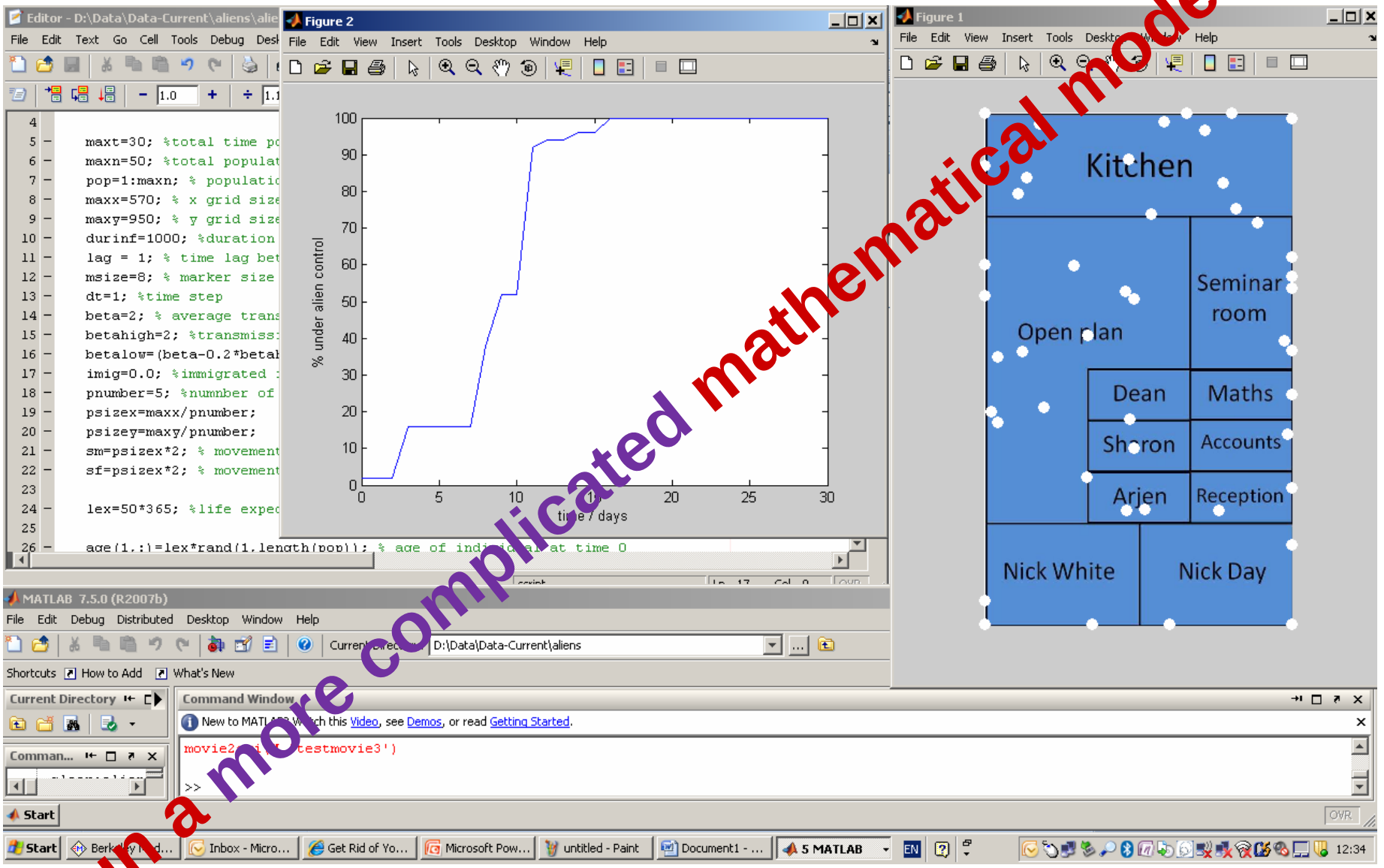
# When Aliens Attack MORU!!!!!

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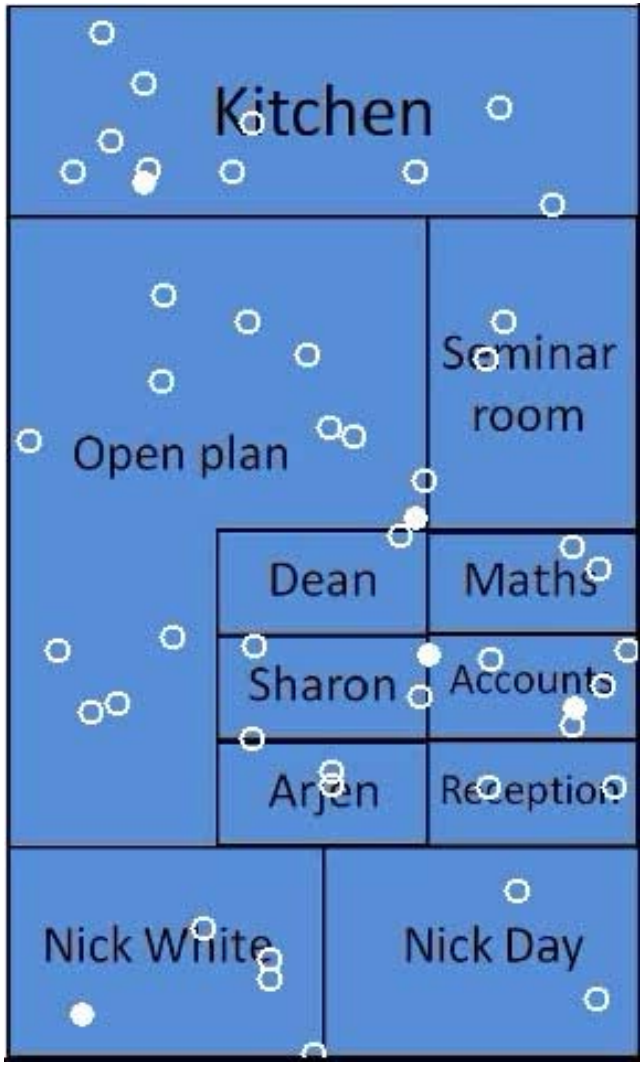
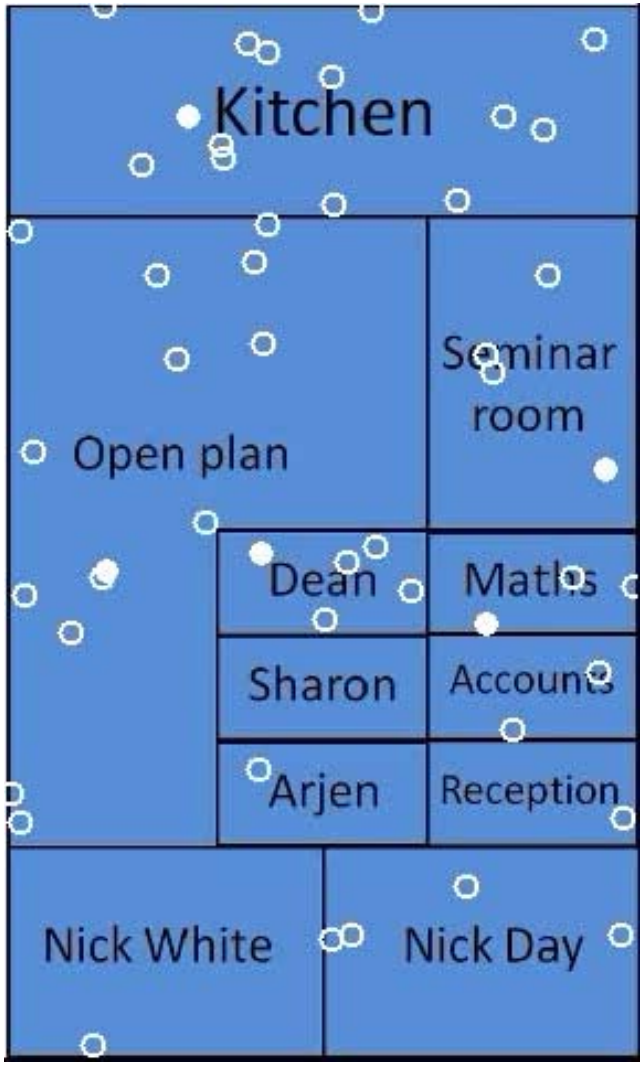
aliensatmoru_formovie.m

# An alien invasion of MORU in 30 days

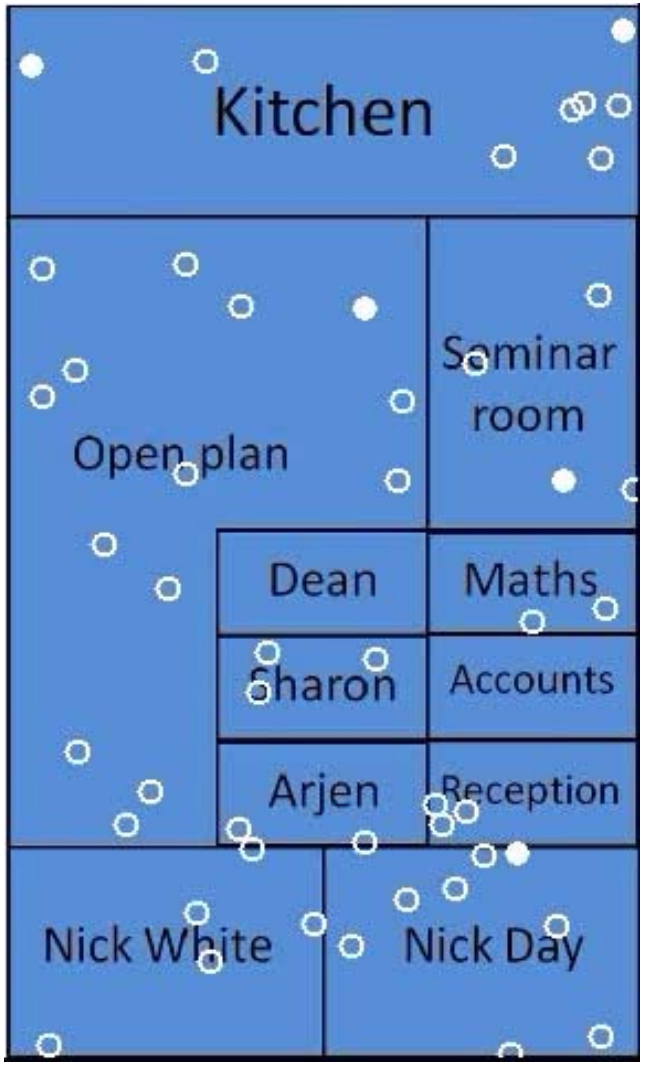
## Alien control for 50 days




## Alien control for 10 days




## Alien control for 5 days



# “Hidden” Messages

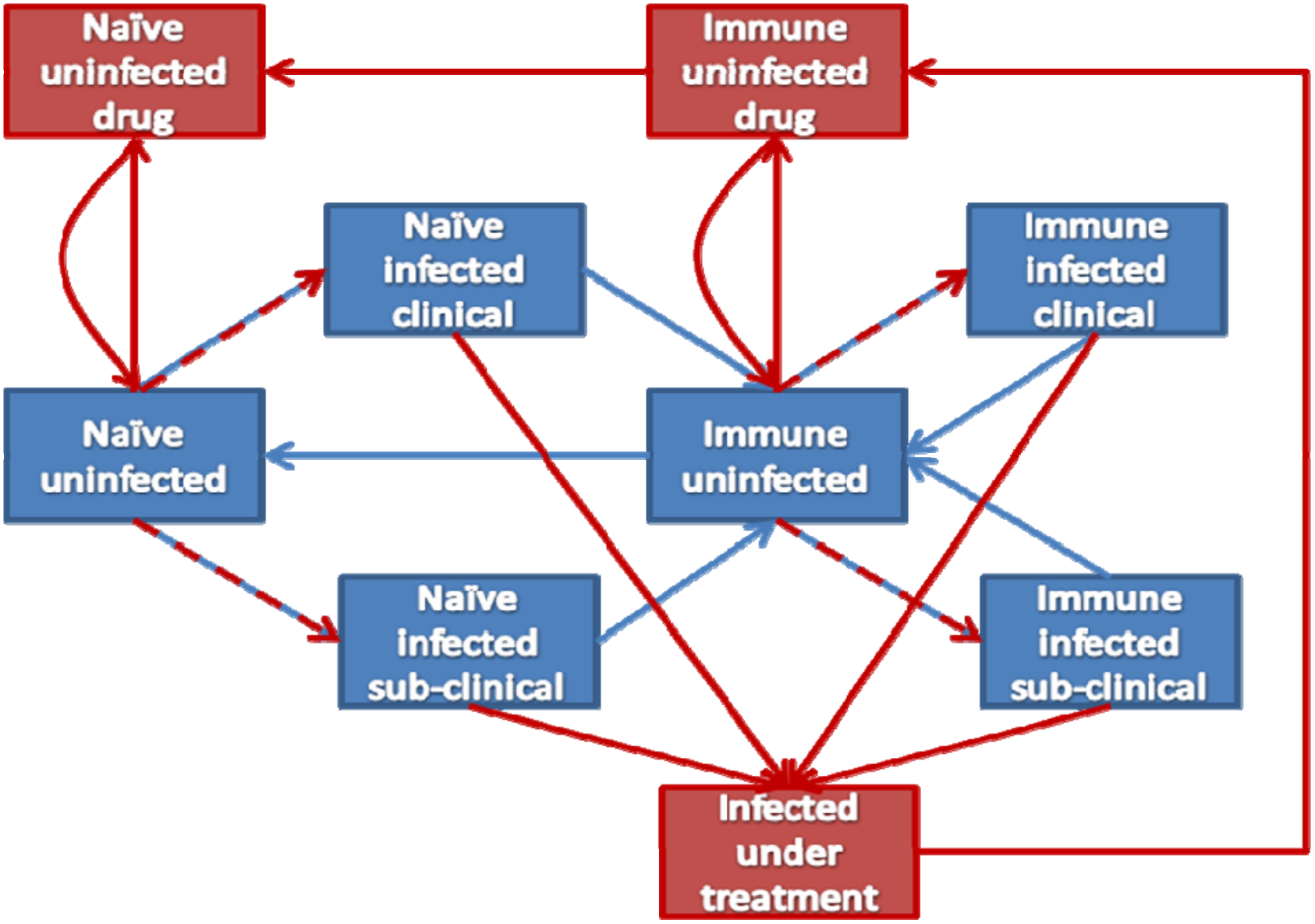
- **SEIR models are used for infectious diseases more often than for alien invasions**
  - They are used to design national control policies
- **Timing is critical**
  - an intervention that works at an early stage may not work later
- **Combining strategies can achieve effective control even when singly they fail**
  - Particularly relevant for malaria
- **Population movement, spatial heterogeneity of risk and immigration of infection significantly affect the course of an epidemic**
  - There are very few data on population movement
  - Models that include population movement are in the early stages of development

# A stochastic meta-population model for the elimination of *P. falciparum* in Cambodia

# Model description

- Meta-population structure
  - population of $1.4 \times 10^7$ divided into 92 patches
  - infectious populations from each patch can infect individuals from other patches based on population behaviour (in this case, based on distance)
- Stochastic variation
  - spatial heterogeneity in transmission
    - low: around Phnom Penh
    - high: North-Eastern Cambodia
    - medium: everywhere else
  - random variation in the number of events that occur in a given time step

# Model Structure



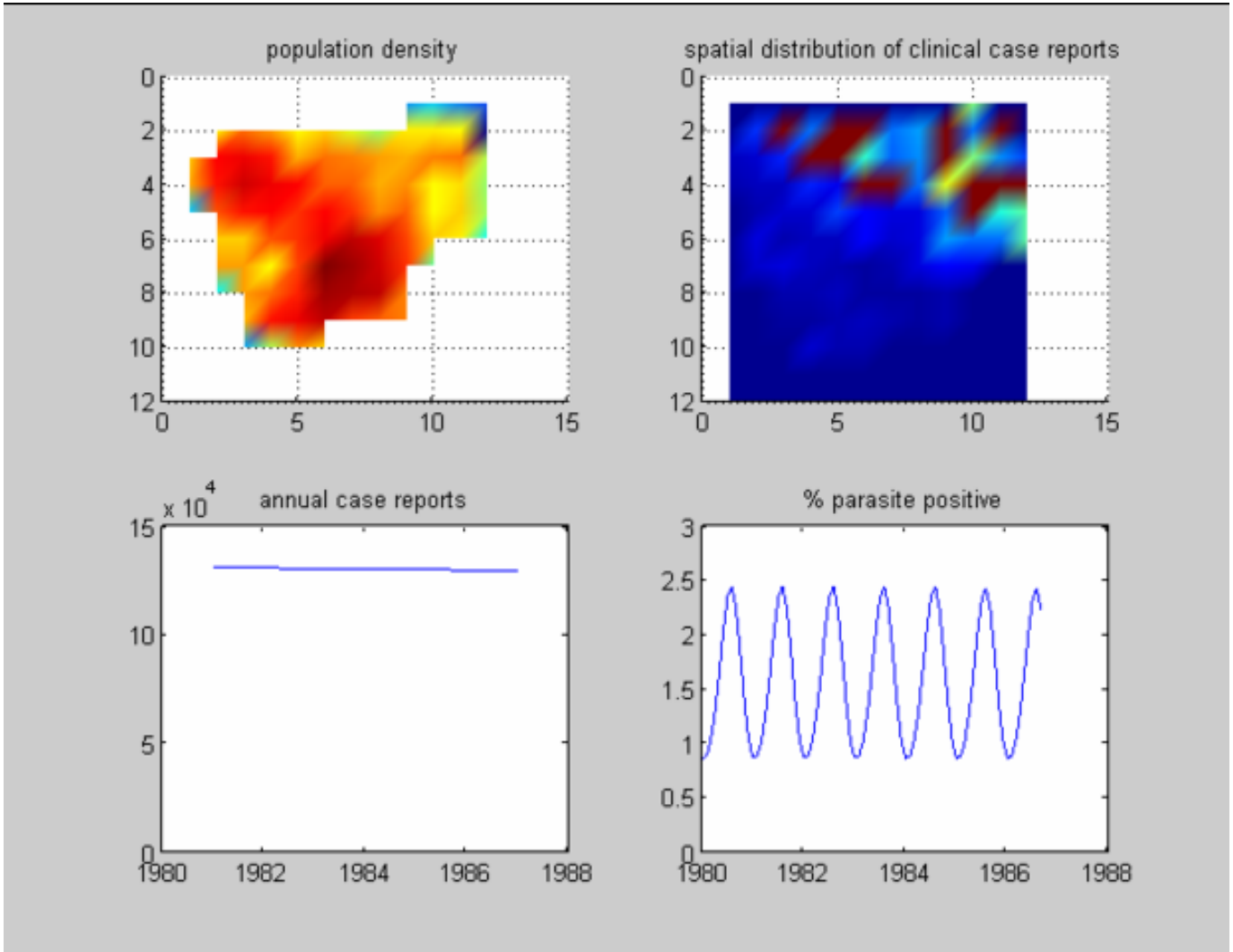
# Model assumptions – infection dynamics

- 30% clinical individuals seek treatment
- 35% clinical cases reported
- average life expectancy 50 years
- 87% of non-immune infections are clinical
- 8% of immune infections are clinical
- untreated infections are infectious for 6 months
- treated infections remain infectious for 1 week
- time between mosquito bite of infected person to inoculation of uninfected person 1 week
- time from inoculation to symptoms 2 weeks
- time between inoculation and infectious stage of human infection 3 weeks
- seasonal variation in transmission with peak biting in March
- immunity lasts for 1 year in the absence of challenge
- duration of active drug in body 4 weeks

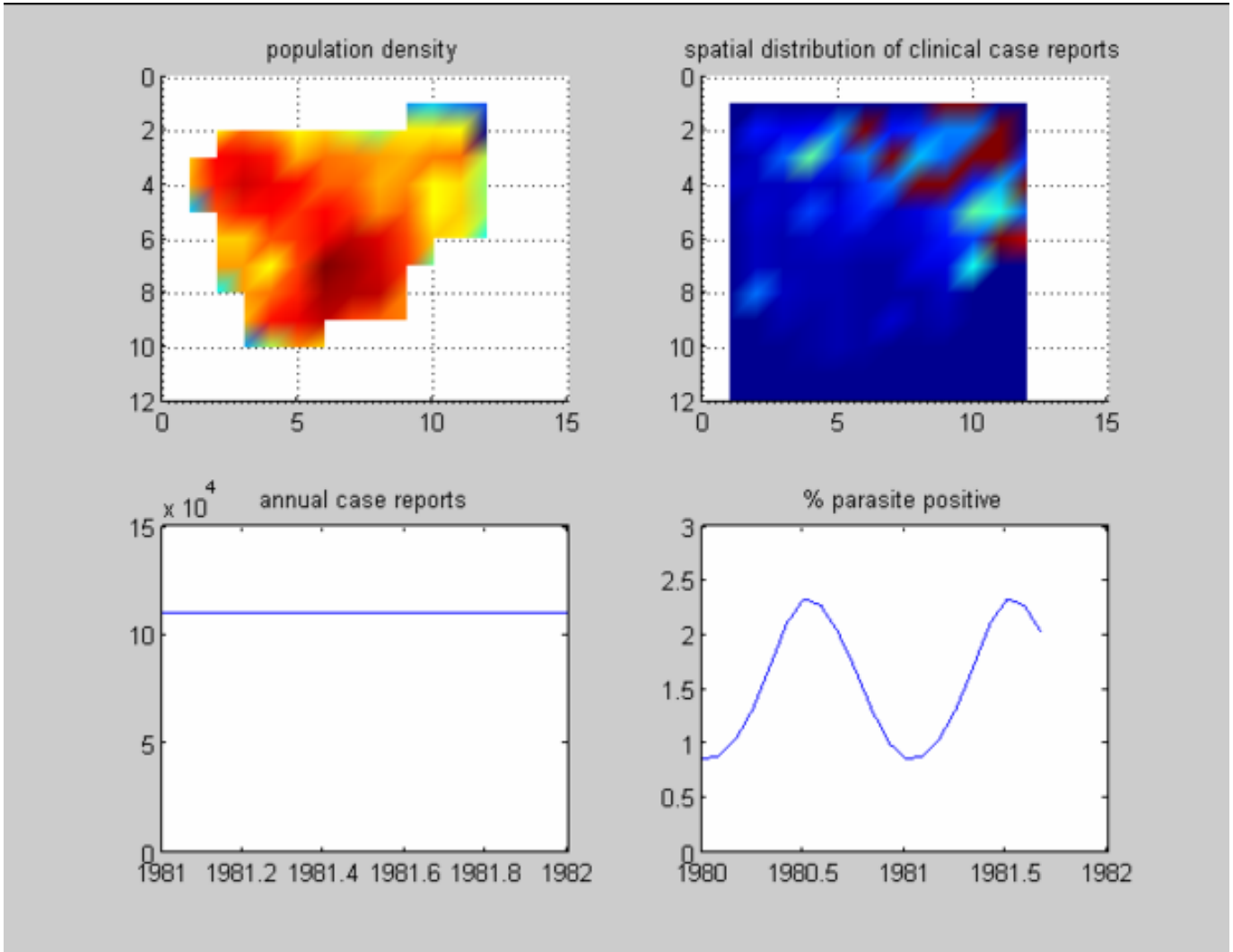
# Model assumptions – interventions

- Year 2000 intervention:
  - increase to 50% clinical individuals that seek treatment
  - ITN with 30% efficacy and 50% coverage
- Mass Screen And Treat 2010:
  - every December for 10 years
  - coverage 50%
  - time to reach coverage 4 weeks
  - sensitivity of test 75%
- Mass Drug Administration 2010:
  - every December for 10 years
  - coverage 50%
  - time to reach coverage 4 weeks

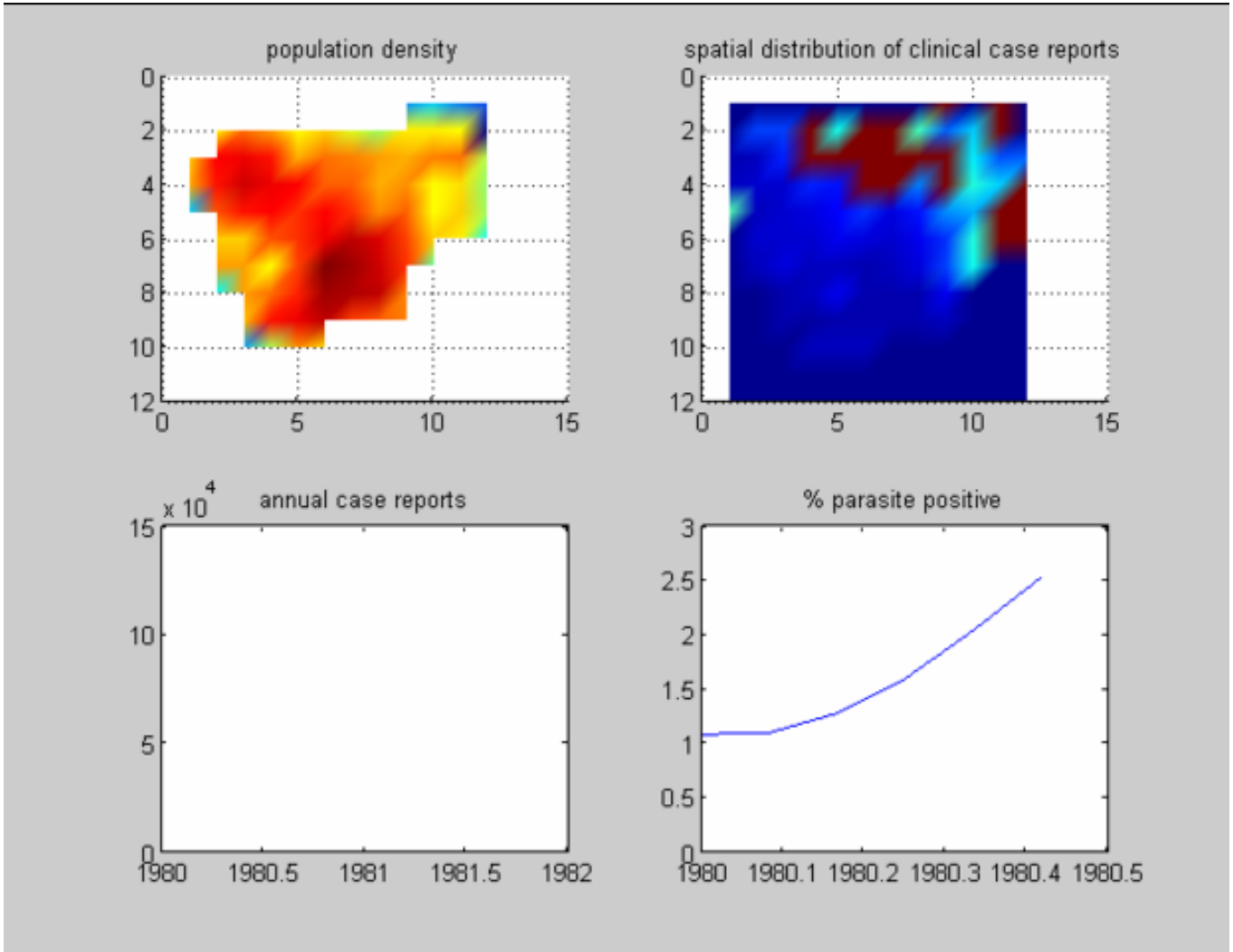
# Year 2000 intervention



# Mass Screen and Treat 2010



# Mass Drug Administration 2010



# Interpretation of preliminary results

- MSAT or MDA should be combined with continued coverage with ITN and increased levels of presumptive treatment
- Annual MSAT or MDA should be applied just before the beginning of the malaria season
- MDA is more likely to succeed than MSAT due to higher coverage of infected individuals and the prophylactic effect in uninfected individuals

# Acknowledgements


MORU

•Modelling Team

- Wirichada Pongtovornpinyo
- Richard Maude
- Sompob Saralamba

•Malaria

- Arjen Dondorp
- Nick Day
- Nick White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CNM Cambodia

- Duong Socheat
- Chea Nguon
- Tol Bunkea
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# Any Questions?