Combining Cattle Movement Data with Stochastic Epidemiological Models to Identify Key Premises for Disease Spread

Theo Pepler, Rowland Kao

EPIC — Scottish Government's Centre of Expertise on Animal Disease Outbreaks

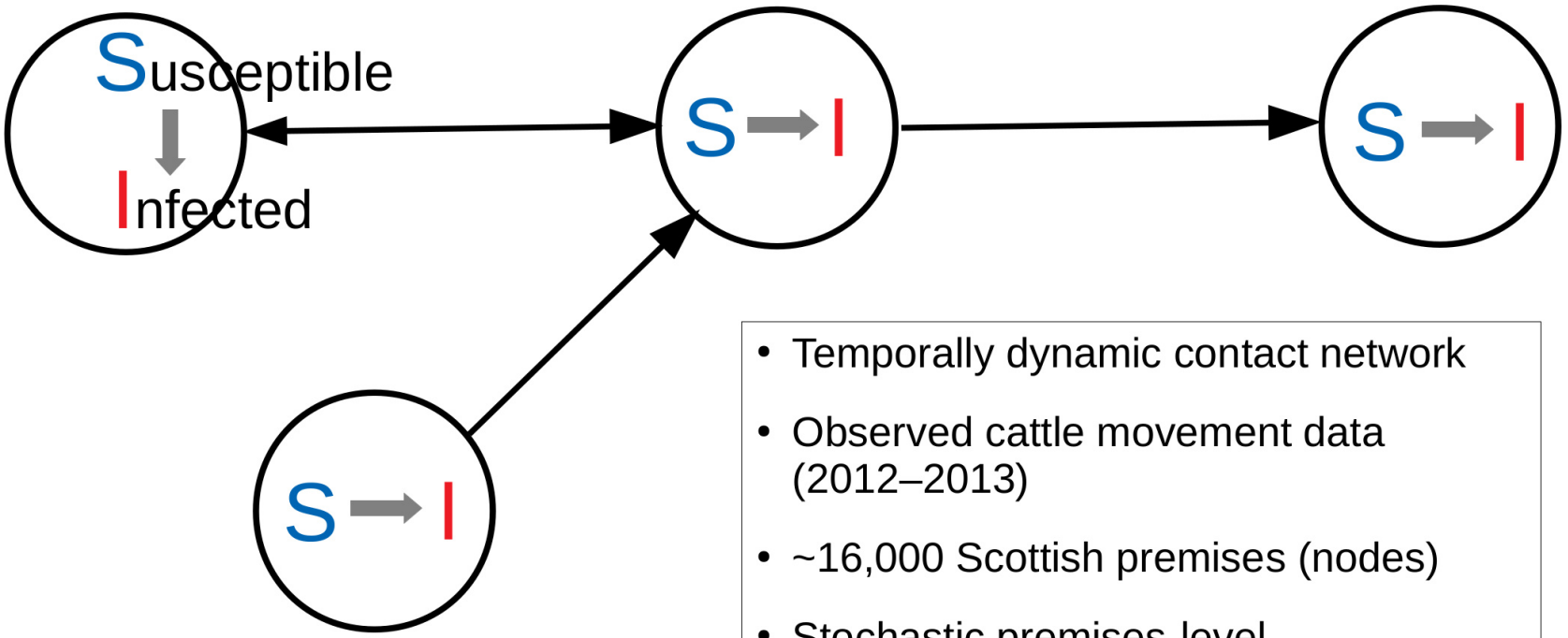
July 11, 2019

Veterinary infectious disease outbreaks in Scotland

Target surveillance to optimise application of limited resources?

Key premises for disease surveillance and control?

Data and simulation model



- Temporally dynamic contact network
- Observed cattle movement data (2012–2013)
- ~16,000 Scottish premises (nodes)
- Stochastic premises-level compartmental model (SI)

- SimInf modelling framework
- Highly infectious disease (like FMD)
- Silent disease spread for 28 days

Simulation experiments

For each of 16,000 Scottish premises, do (200 times):

1. Seed single infected animal on randomly chosen day
2. Follow up network for 28 days

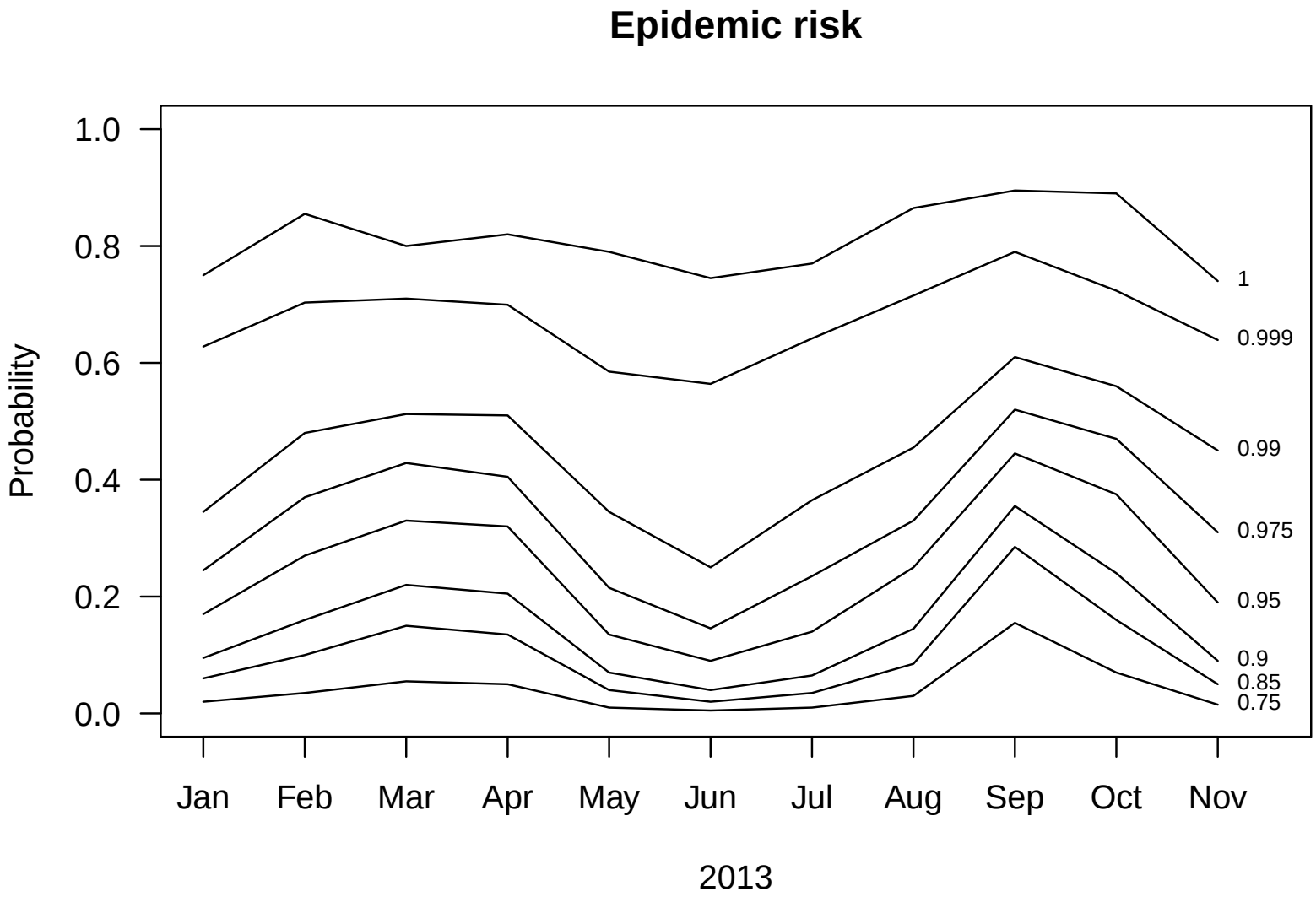
We did this for different time periods:

- (months) Jan, Feb, . . . , Nov 2013
- (years) 2012 vs. 2013

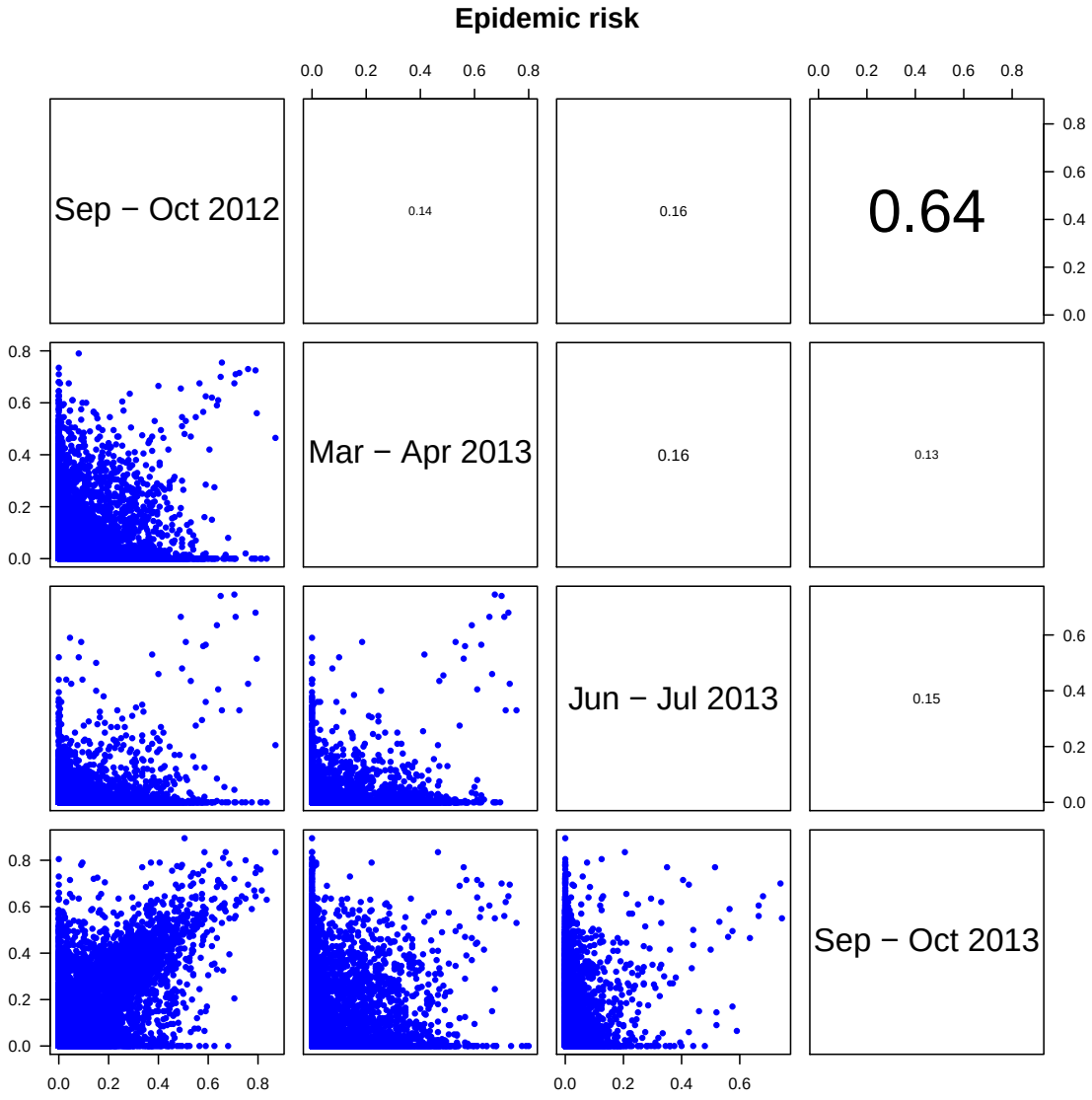
Five summary measures

- Number of infected animals
  How many animals to cull/vaccinate/deal with?
- Number of affected premises
  How many premises to de-populate/control?
- Number of runs involved
  Where are the conduits for infection?
- Risk of epidemic outbreak (5+ premises)
  Which premises are most risky for initiating epidemic outbreaks?
- Risk of *large* epidemic outbreak (20+ premises)

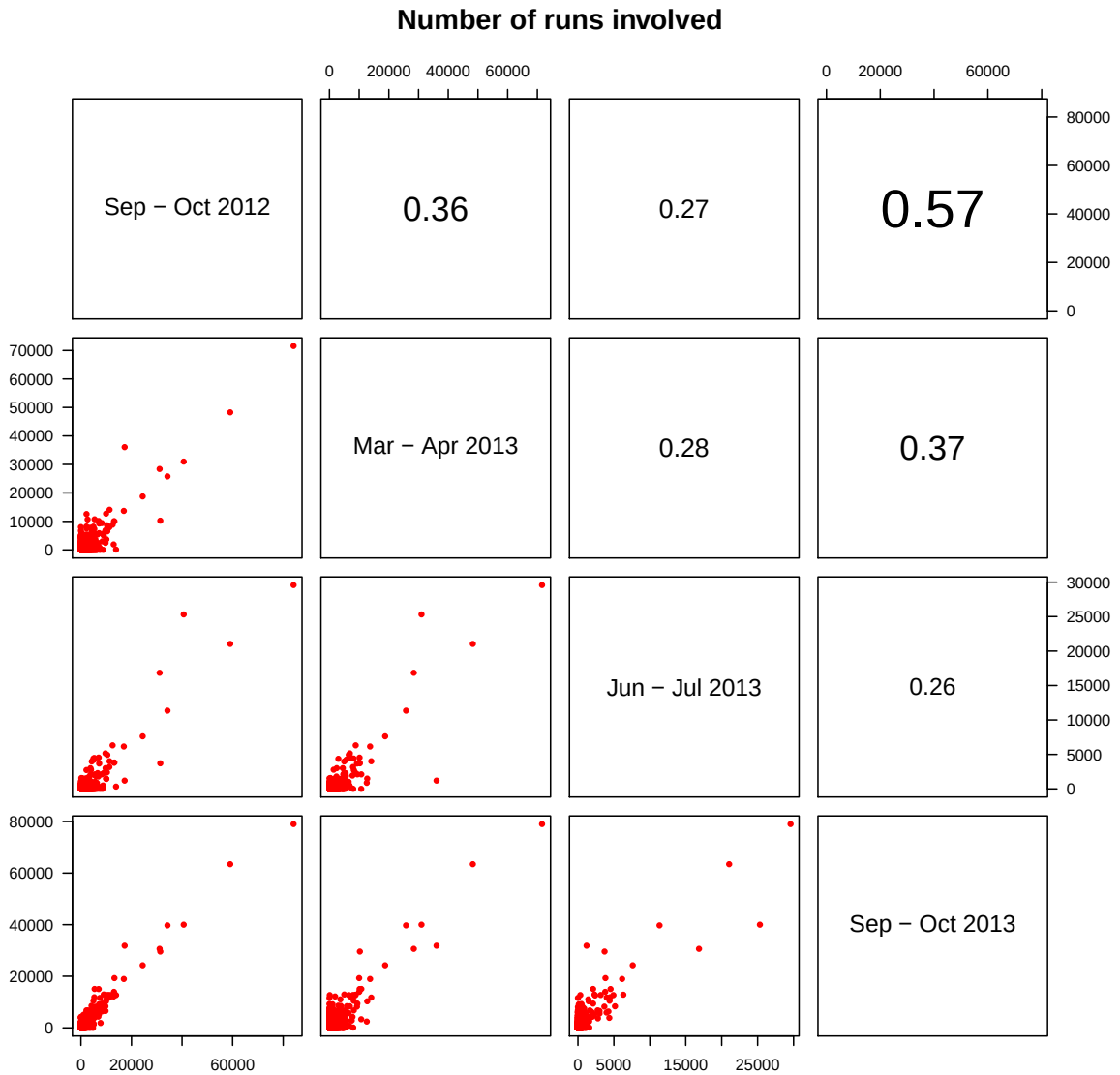
Consistency of measures: *within* year (1)



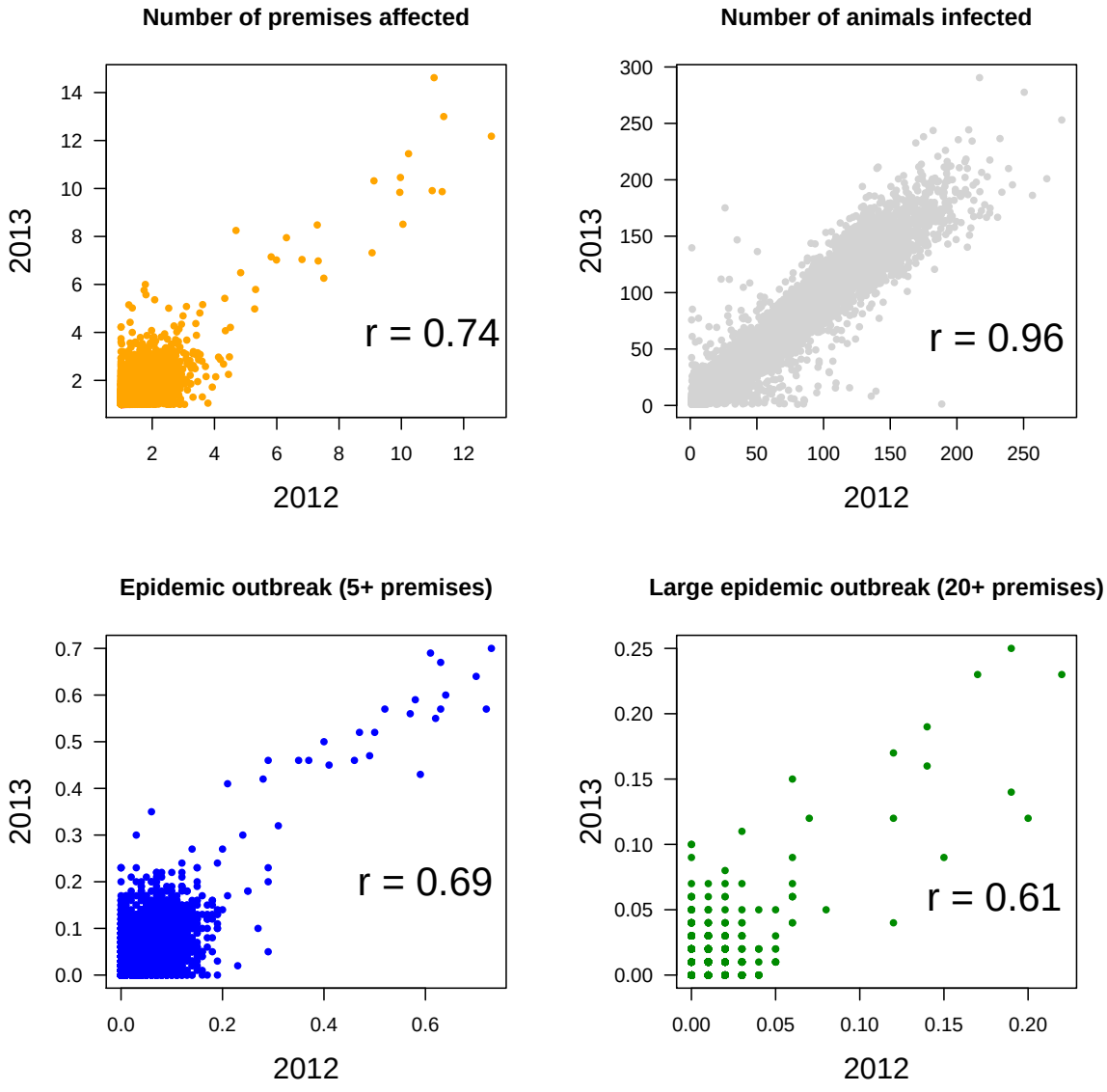
Consistency of measures: *within* year (2)



Consistency of measures: *within* year (3)

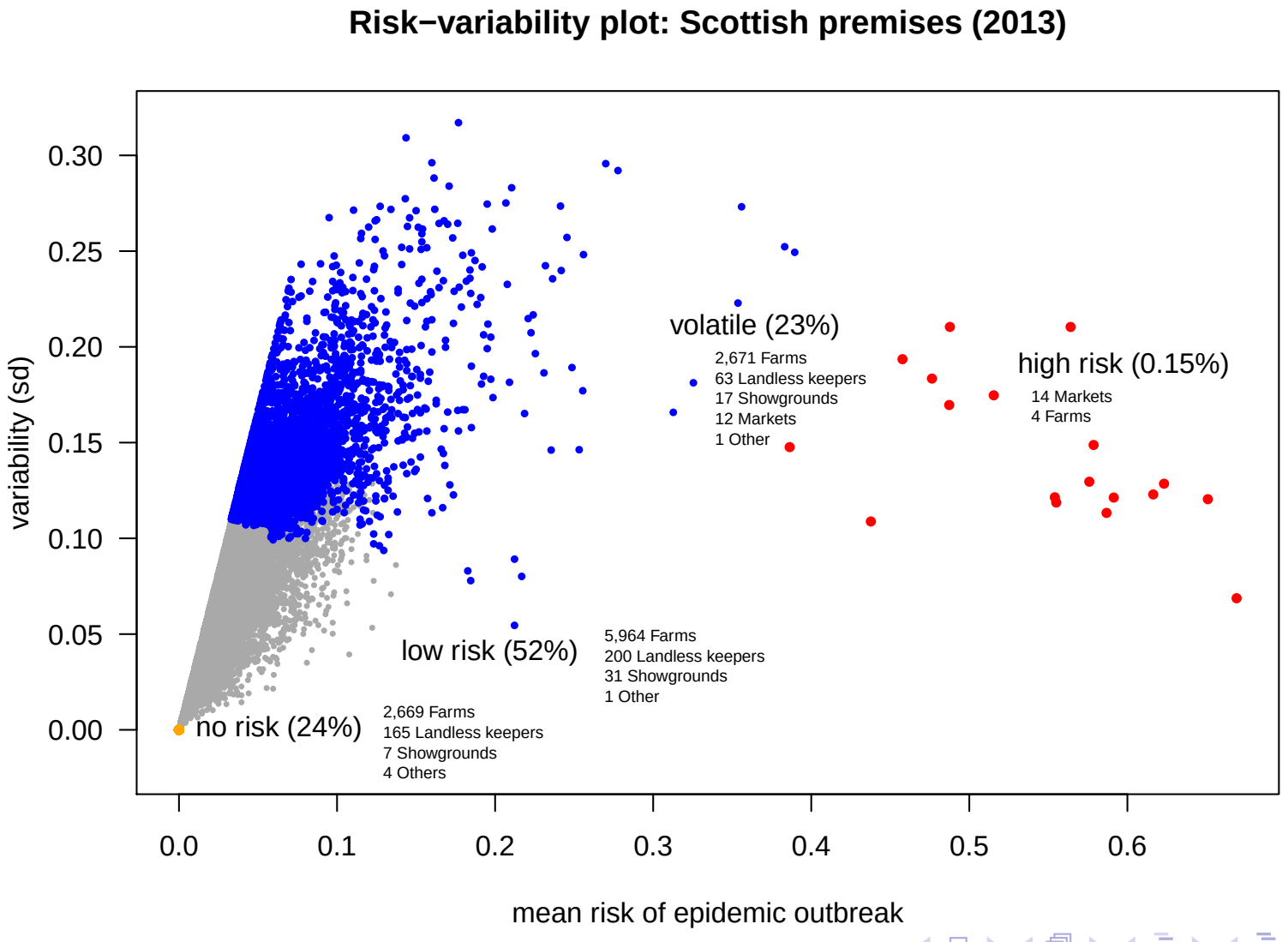


Consistency of measures: *between* years



Classification of premises: epidemic risk

Hierarchical cluster analysis, complete linkage, 3 (+1) clusters



Policy implications

1. For highly infectious diseases spread primarily by direct animal-to-animal contact, premises-level risk depends more on position in network than on premises characteristics
2. Focus on "volatile" (23%) and "high-risk" (0.15%) premises
   - for disease prevention policy measures
   - prioritising farm visits
3. Focus on "conduit" premises (i.e. high involvement in outbreaks) for disease surveillance and control in event of outbreak

Acknowledgments

Data provision
Animal Plant and Health Agency (APHA)
EPIC Data Team

Funding
Scottish Government Rural and Environment Science and Analytical Services Division (RESAS)

Thank you!