

Covid-19 Spatial Model

May 2020

Spatial model conceptualised and implemented by Sally Archibald, Robert Bennetto, Ronald Richman, and Zaid Kimmie with inputs from Francois Engelbrecht, Tom Moultrie, Pravesh Debba, Sheetal Silal, Juliett Pulliam, Gesine Meyer-Rath and Harry Moultrie

Why Spatial Models?

- ◆ Underlying assumption of compartmentalized models is 'homogeneous interaction' – each person in the model is equally likely to interact with any other person
 - But we know that interaction is spatially constrained ...
- ◆ The spread of the infection differs across spatial levels – want to predict timing and scale of demands on health system at finer scales
- ◆ Also want to make predictions about where new infections are likely to occur

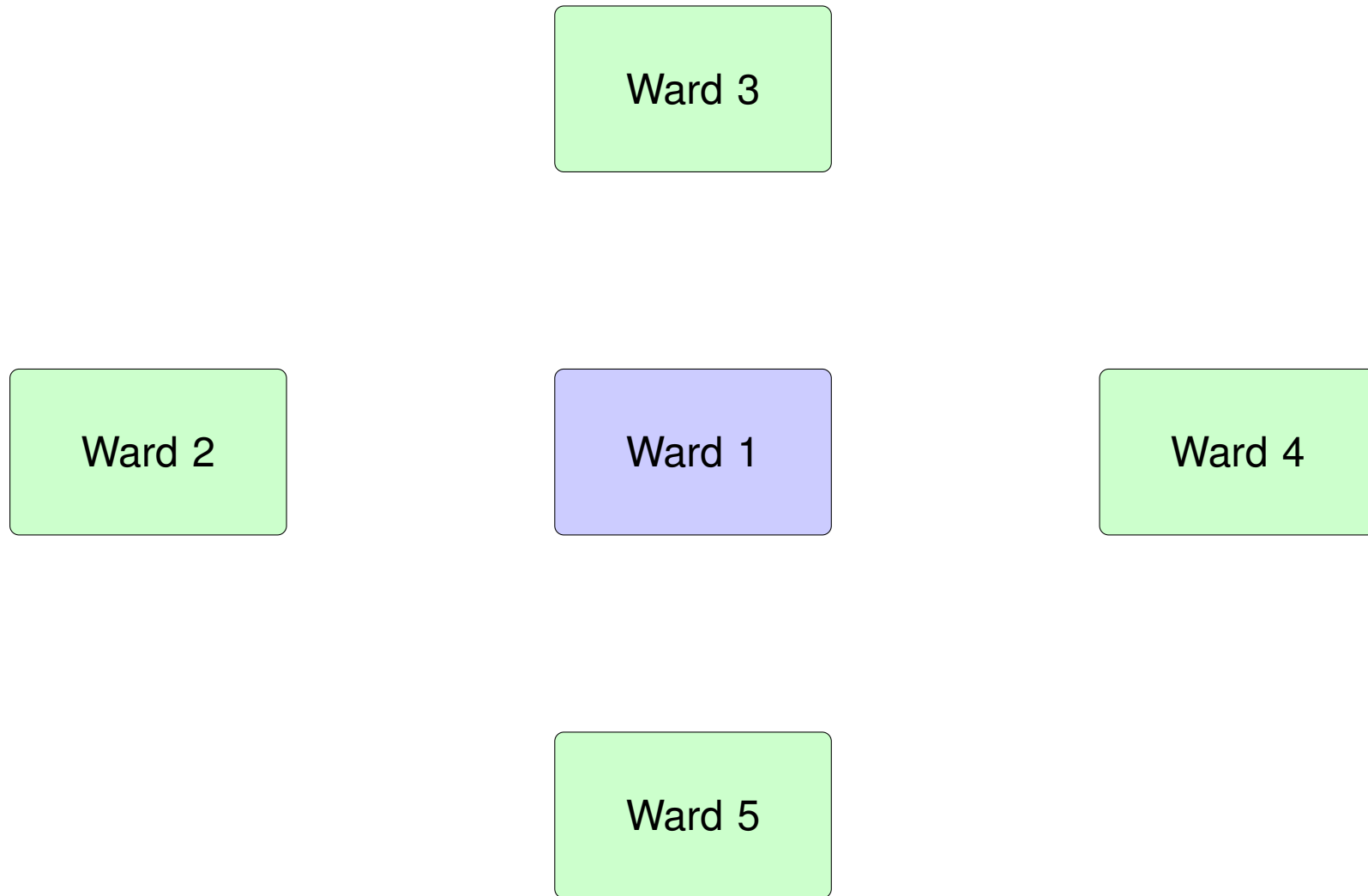
Spatial Scale

- ◆ Choice of spatial scale important – we have chosen **wards** as a compromise between granularity and computational requirements
 - 4,394 wards; reasonable data on population demographics, socio-economic conditions
- ◆ Finer scales give better information about local phenomena (hot spots linked to institutions for example) but need more detailed mobility data and are computationally more expensive

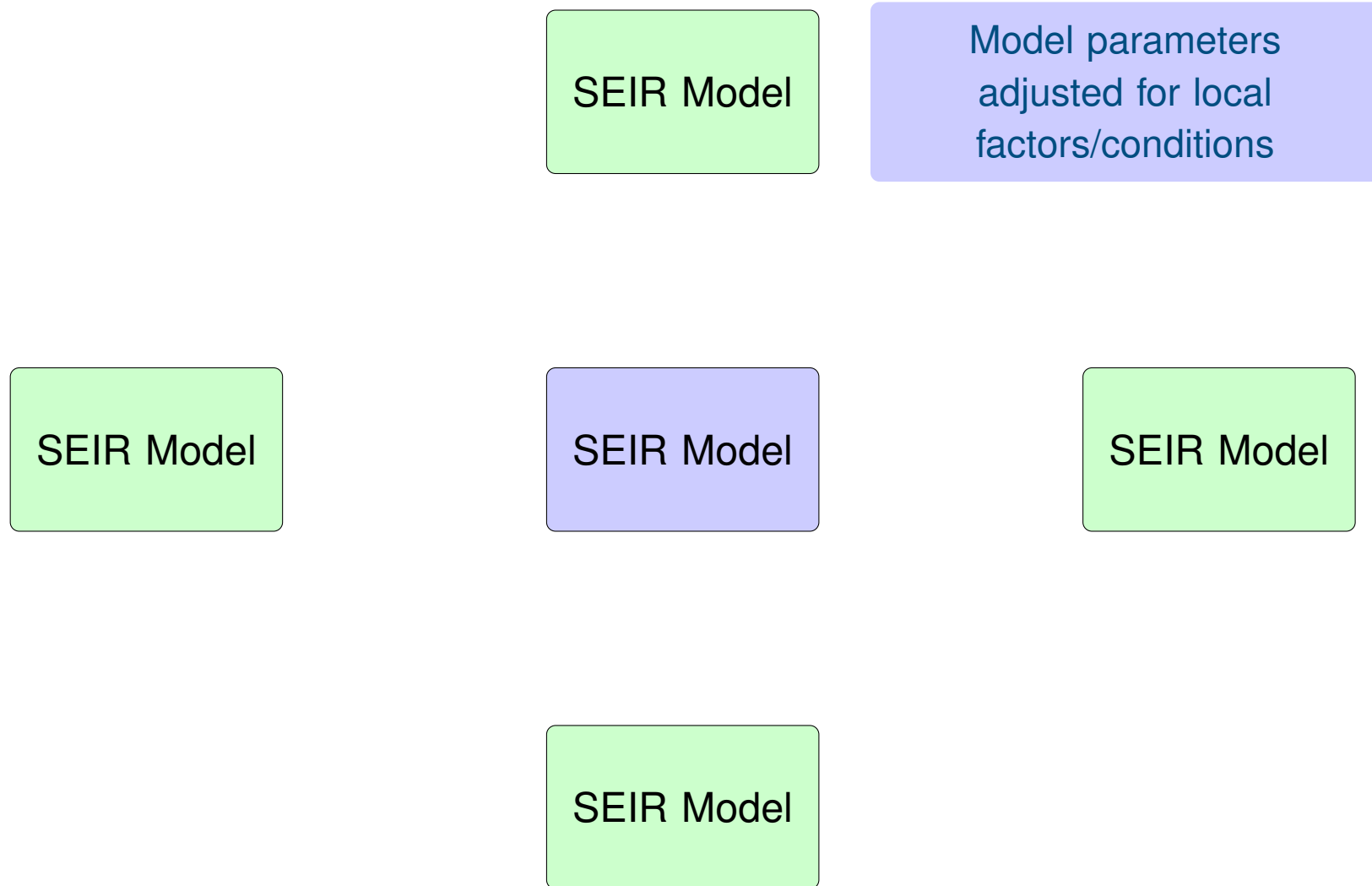
Requirements for Spatial Model

- ◆ SEIR model applied at ward level
- ◆ Some way of estimating movements of people between wards, preferably taking into account effect of external interventions
- ◆ A method for taking into account the interaction between movement and SEIR model outputs

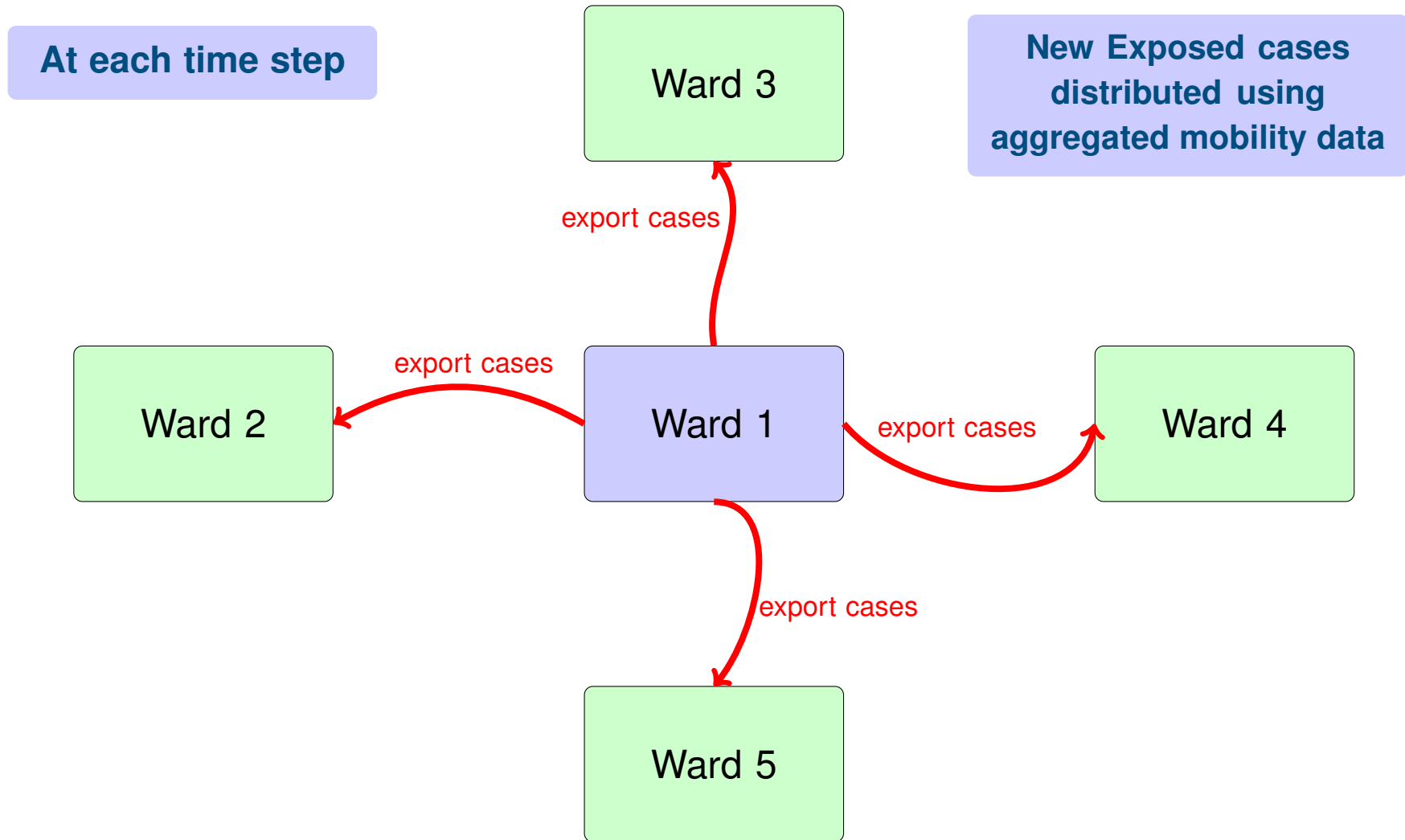
Model at Ward Level



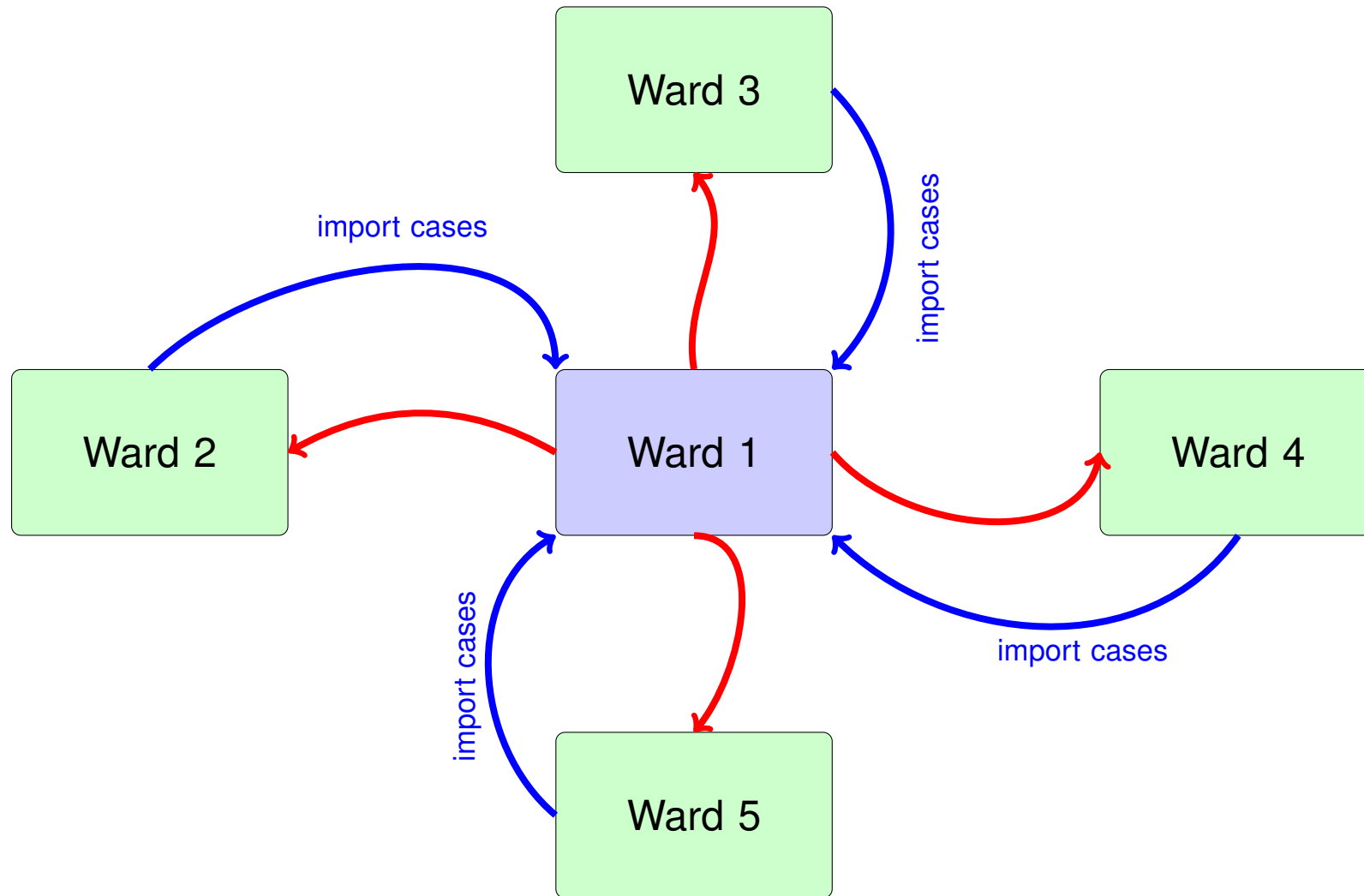
SEIR Model within each ward



Spatial Model – Distributing Cases



Spatial Model – Distributing Cases



Sources of Variability

- ◆ Spatial spread is stochastic not deterministic
 - use mobility data to say how likely it will be the infection will spread to particular areas
- ◆ SEIR model parameters are also subject to uncertainty

Mobility Matrix – Example

	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5
Ward 1	0.4	0.2	0.1	0.0	0.3
Ward 2	0.2	0.5	0.1	0.0	0.3
Ward 3	0.0	0.2	0.6	0.0	0.2
Ward 4	0.0	0.2	0.1	0.5	0.3
Ward 5	0.1	0.2	0.1	0.2	0.4

Mobility Data

- ◆ Vodacom aggregated daily movement data
- ◆ 2 March to 18 May
- ◆ Captures movement patterns prior to any intervention (2 - 15 March); Social Distancing (17 - 24 March); Lockdown (25 March - 30 April); and Level 4 lockdown (1 May - 18 May)

Mobility Data

- ◆ Using movement patterns from the pre-intervention phase as a reference, with movement for more than 5km and more than 50 km:

National	$\geq 10\text{km}$	$\geq 50\text{km}$
No Interventions	1.00	1.00
Social Distancing	0.90	0.95
Lockdown	0.58	0.36
Level 4	0.69	0.53

Current Status

- ◆ Implemented on Centre for High Performance Computing
- ◆ Able to take into account local vulnerability measures and effects of climate
- ◆ Produces estimates of numbers of infected at ward level, outputs aggregated up to district, municipal and provincial levels
- ◆ Can account for differential implementation of interventions at different spatial levels (different lockdown levels for different time periods for each municipality, for example)

End

Thank You