Local cluster detection using spatial scan statistics

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1. Introduction
2. Scan statistics
3. Common SaTScan models
4. SaTScan and QGIS

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  - Test whether a disease is **randomly distributed** over space, over time or over space and time.
  - Evaluate the statistical significance of **disease cluster alarms**.
  - Perform repeated time-periodic disease surveillance for **early detection** of disease outbreaks.

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- Imposes circles of different sizes (from zero up to a defined proportion of the population size) on the geographic area
- For each circle, computes a likelihood ratio statistic based on the number of observed and expected cases within and outside the circle and compared with the likelihood L_0 under the null hypothesis.

For each window, SaTScan calculates the likelihood, proportional to:

$$\left(\frac{n}{\mu}\right)^{n}\left(\frac{N-n}{N-\mu}\right)^{N-n}$$

where

- n = number of cases inside circle
- N = total number of cases
- μ = expected number of cases inside circle

The scan statistic

SaTScan:

- Maximises the likelihood over all possible circles – this is the **scan statistic**.
- Tests significance by performing Monte Carlo hypothesis testing:
  - Redistributes cases randomly and recalculates the scan statistic many times (e.g.999).
  - Computes a *p*-value, which is the proportion of scan statistics from the Monte Carlo replicates which are greater than or equal to the scan statistic for the true cluster.

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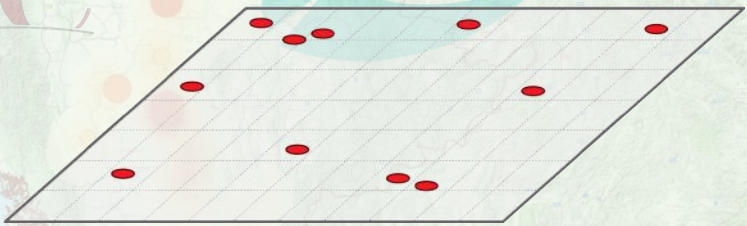
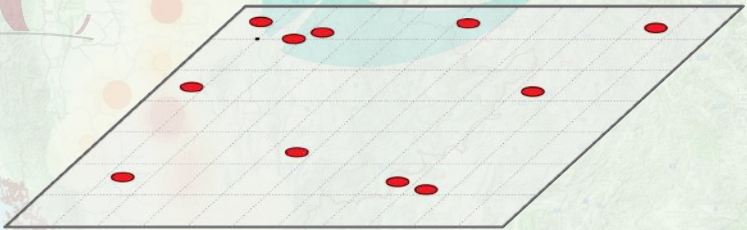
The spatial scan statistic (grid points)

- Study area with observed events.



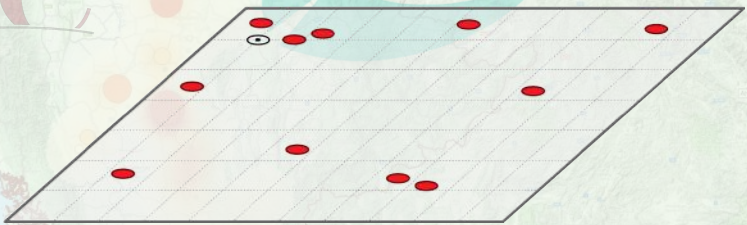
The spatial scan statistic (grid points)

- Place a point on the grid.



The spatial scan statistic (grid points)

- Circular scanning window with radius zero to upper limit.
- Observed and expected numbers of events are recorded.



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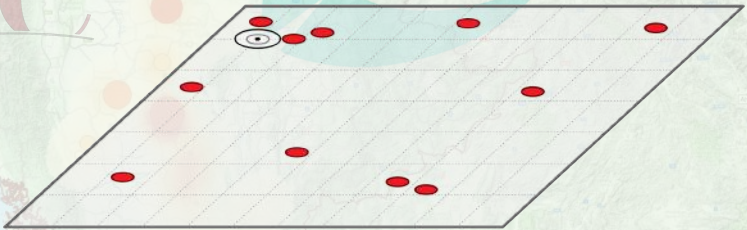

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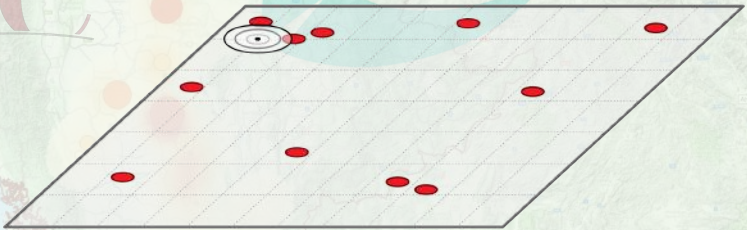

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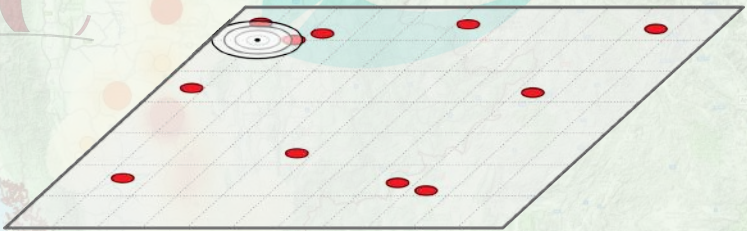

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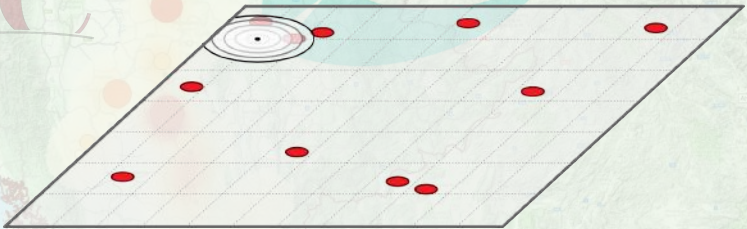

The spatial scan statistic (location ID points)

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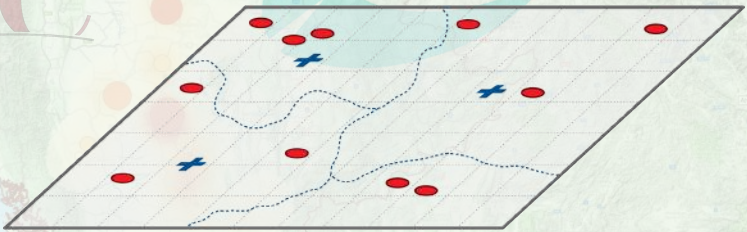
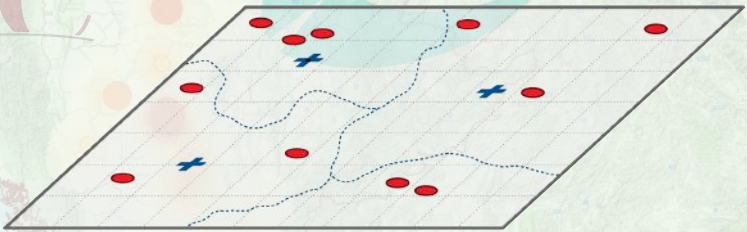


The spatial scan statistic (location ID points)

- Coordinates of a location ID (centroid).



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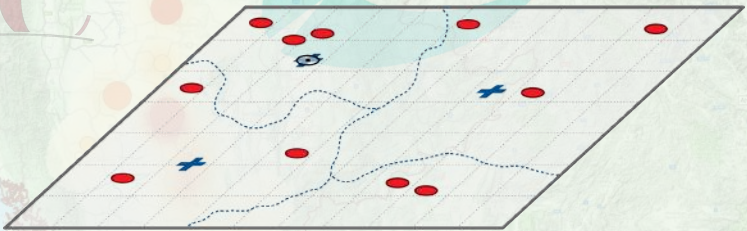

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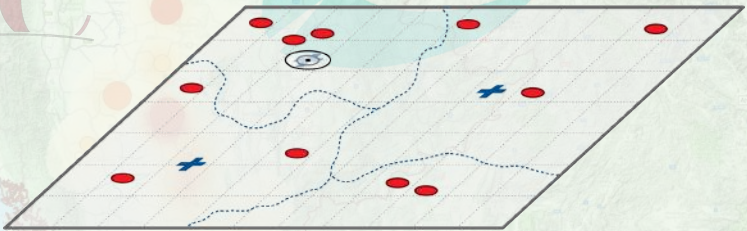

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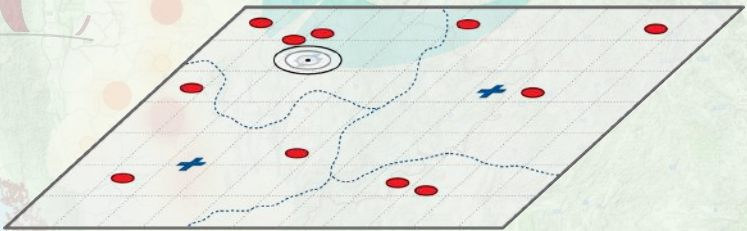

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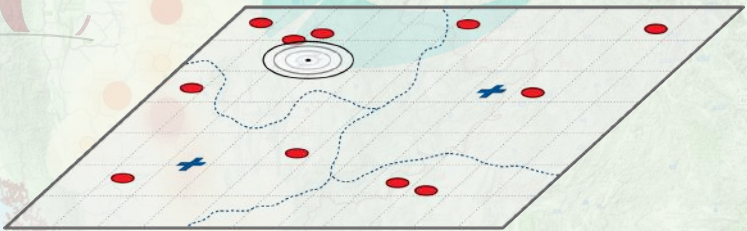

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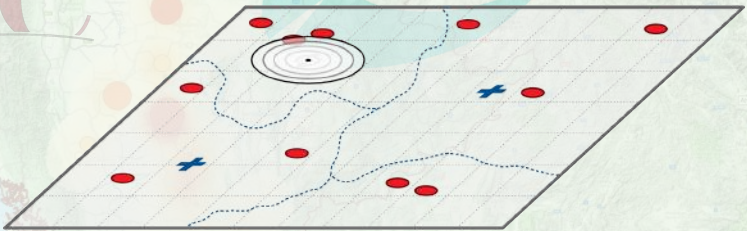
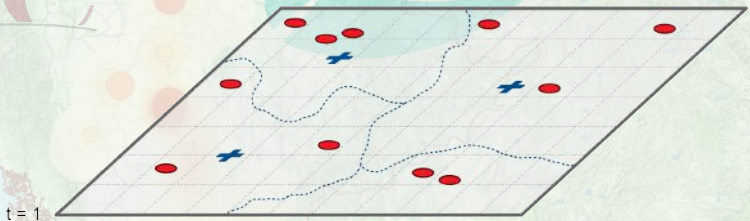


Space-time scan statistic

- Study area with observed events, at times t_1 to t_4.



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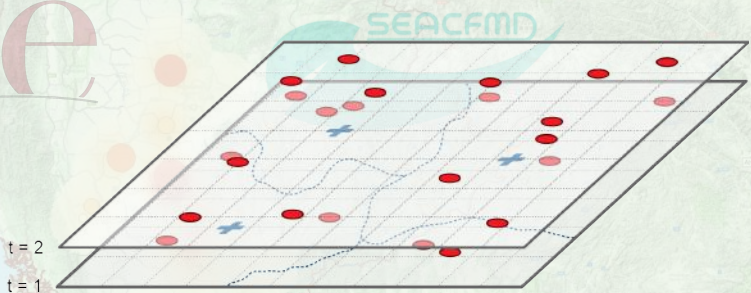

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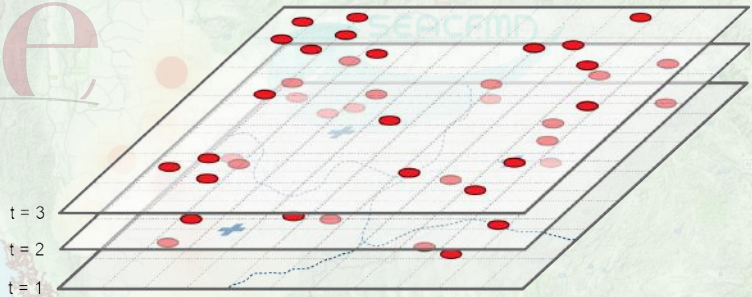

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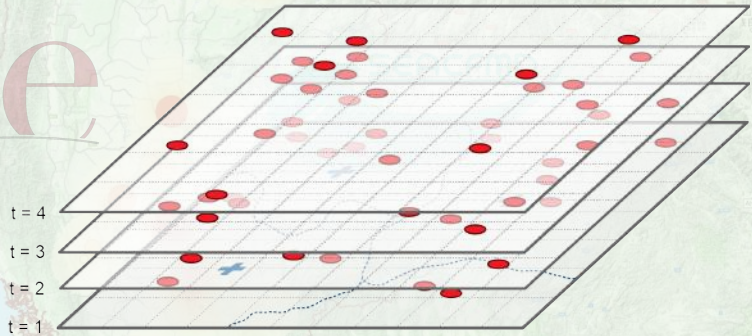

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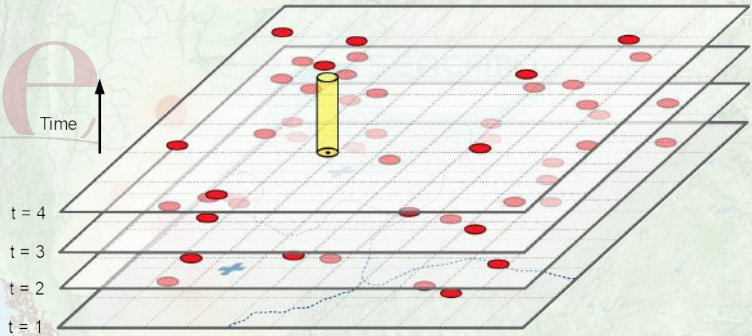
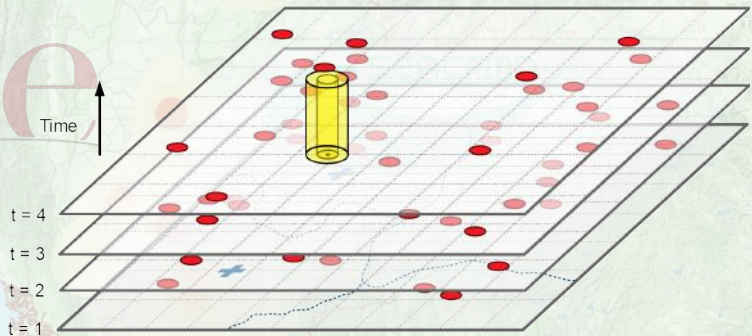


Space-time scan statistic

- Cylindrical scanning window.
- Observed and expected numbers of events are recorded.



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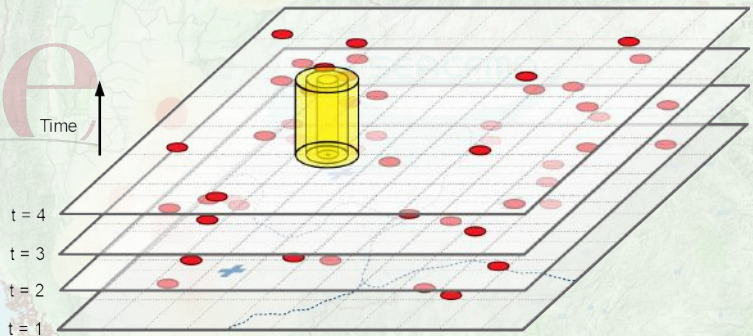

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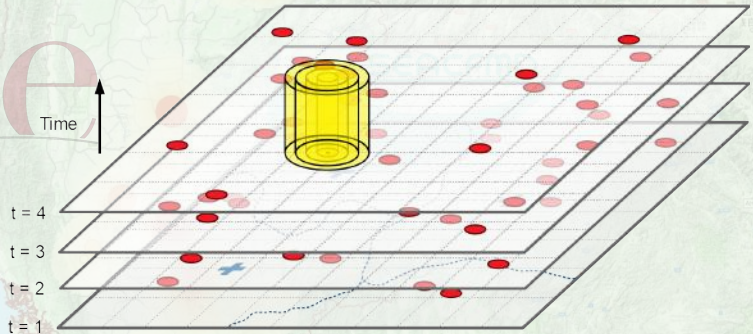

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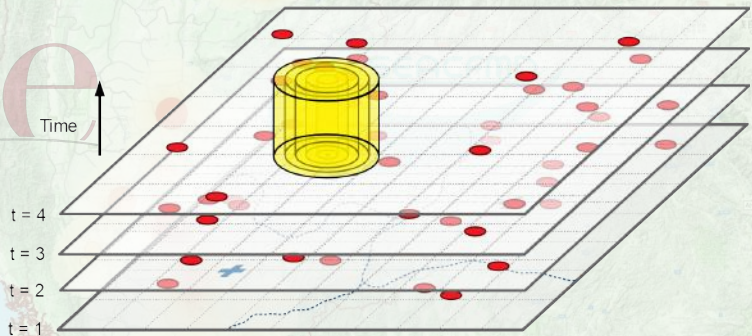


Three types of models you may use:

1. **Bernoulli model:**
   - Animals have 0 / 1 disease status
   - A set of cases and controls
   - Purely temporal / spatial or space-time scan statistics

Three types of models you may use:

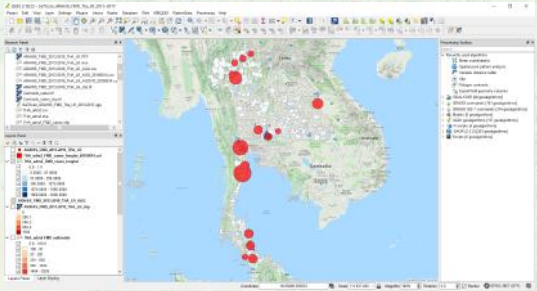
2. **Poisson model:**
   - The number of cases in each location is Poisson distributed
   - Under the null hypothesis, the expected number of cases in each area is proportional to its population size
   - Therefore, required information for the population at risk
   - Purely temporal, purely spatial and space-time

Three types of models you may use:

❸ **Space - Time Permutation model:**

- Requires only case data with information about spatial location and time
- Assumes homogeneous population changes over the scanning period

- Data preparation steps:
  - The purely spatial Poisson model requires **aggregated data** (to District level)
  - We also need to prepare **population data** (expected number of cases) and **location data** (centroids of District polygons)



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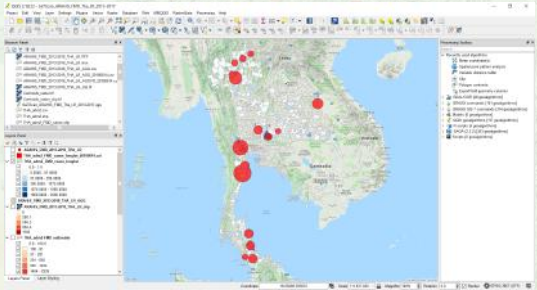

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- SaTScan does not produce map output, but it generates shapefiles which can be loaded into QGIS.