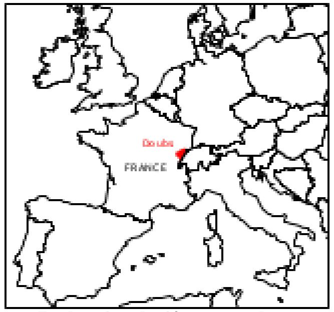
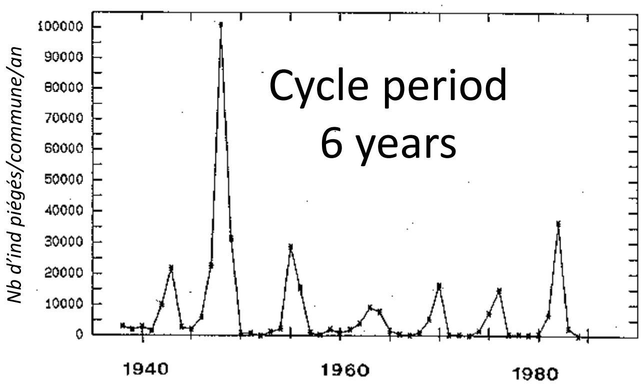
Dispersal, Landscape and Travelling Waves in Cyclic Fossorial Water Vole Populations

Journées Rongeurs, 24-25 septembre 2015

Jura Mountains

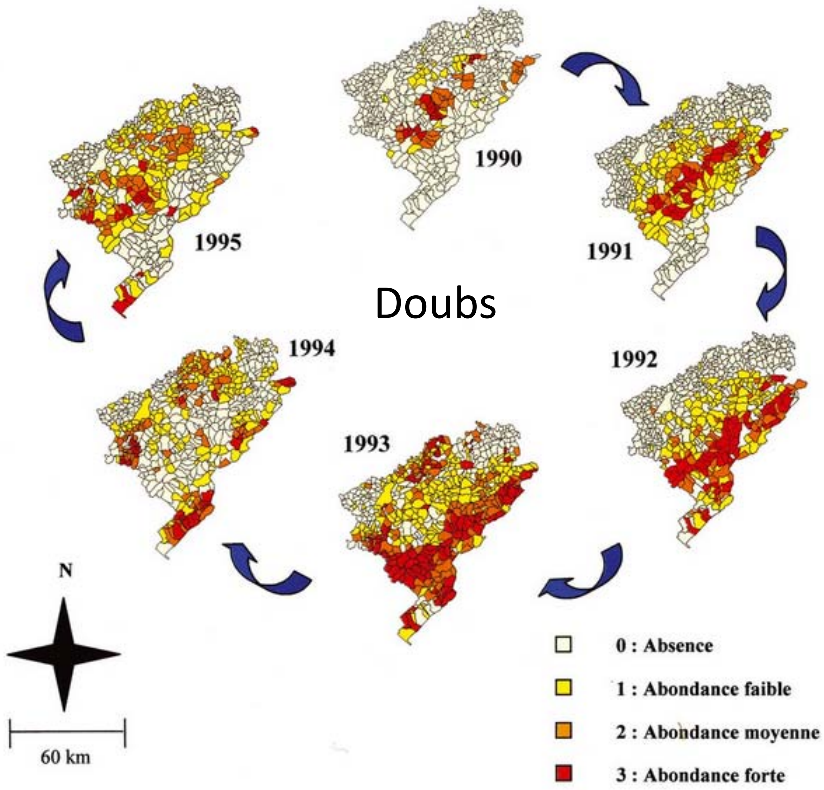


Localization of Doubs département in Europe



Spatial Dynamics of Outbreaks

⇒ FREDON: Monitoring of population abondance at the communal scale for outbreak control



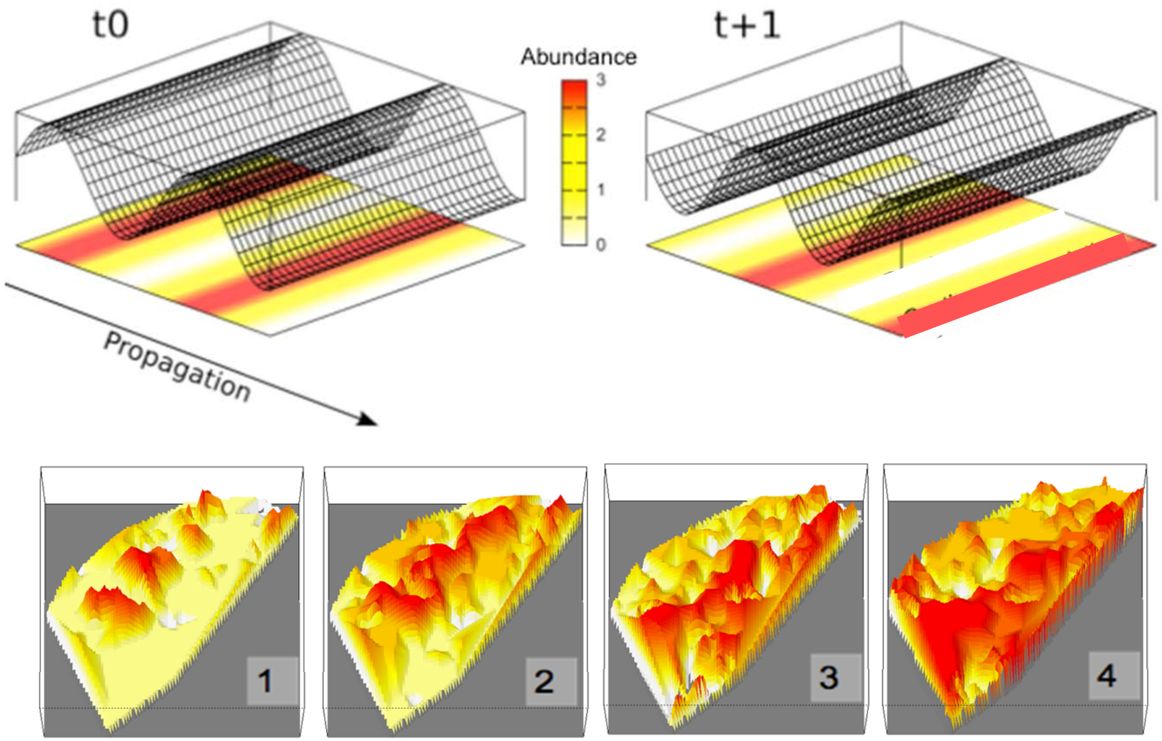
Giraudoux *et al.* 1997 : 1 cycle (1989-1994) suggest :

=> outbreaks are not synchronous

=> outbreaks spread as a Travelling wave at a speed of ~ 10km/year

Travelling Waves?

⇒ Spatial phase shift in synchrony which in time gives the appearence of a wave



⇒ No massive movement of individuals (high dispersal synchronise populations)

Theory on Travelling Waves Emergence

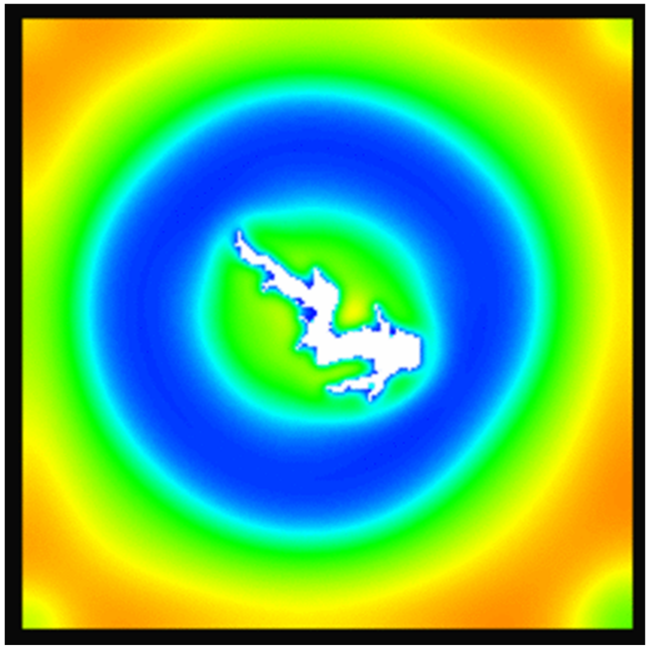
⇒ Interacting species to generate cyclicity (predator-prey, plant-herbivore, etc)
⇒ A diffusion process (dispersal of individuals of either one or all species involved in cyclicity)

⇒ landscape heterogeneity is instrumental in generating travelling waves

- Gradients in habitat quality => impact population growth (Johnson *et al.* 2004, 2006)

⇒ Larch budmoth in Alps Mountains (Johnson *et al.* 2010)

- Large-scale obstacles => impact dispersal (Sherrat *et al.* 2002, 2003)



Large-scale obstacle modelled under absorbing boundary conditions:

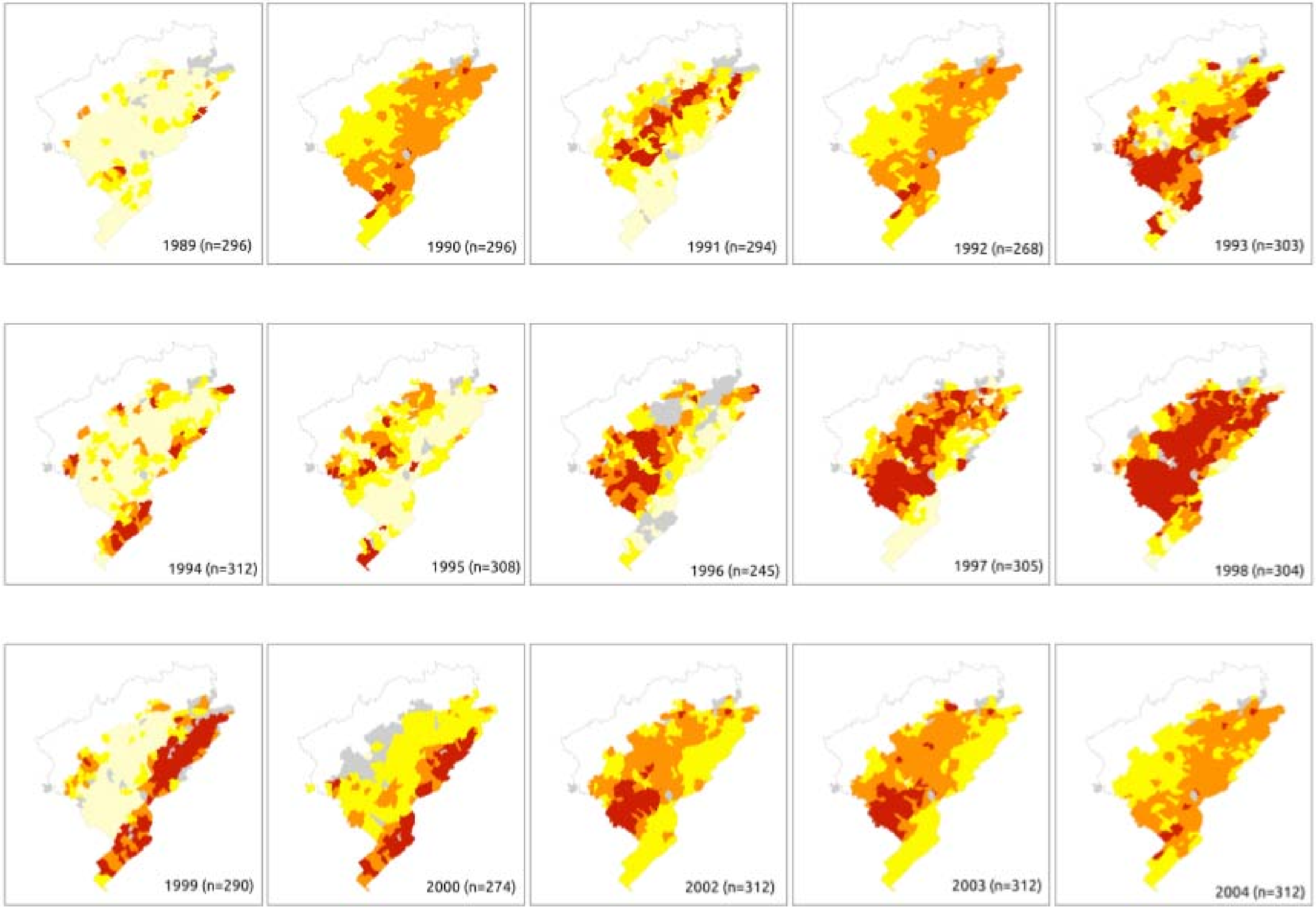
⇒ Linear TW moving away perpendicular to obstacles

⇒ No real empirical evidence

Dispersal, landscape and TW in cyclic voles in the Jura Moutains?

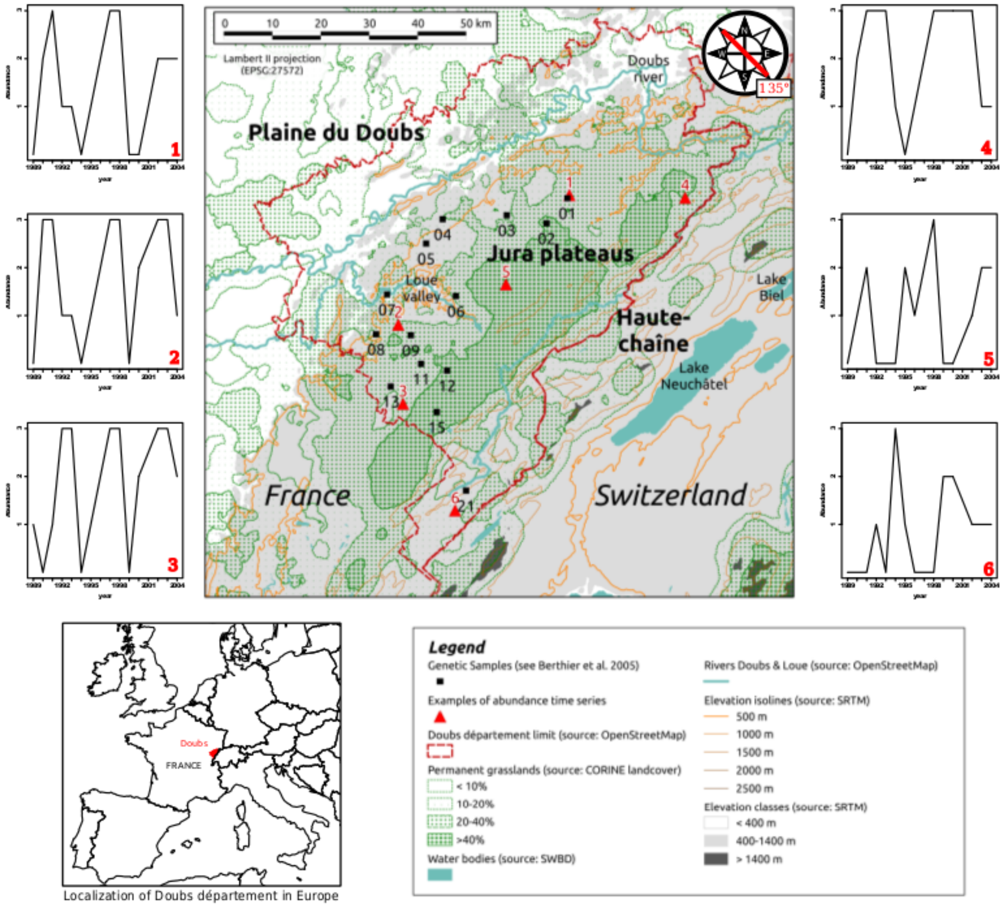
⇒ 16-years abundance data from the FREDON in the Doubs departement

- Can we detect and estimate TW parameters from long time series of abundance?



Dispersal, landscape and TW in cyclic voles in the Jura Moutains?

⇒ Genetic data from 14 populations:
⇒ Landscape data (grassland ratio and elevation)



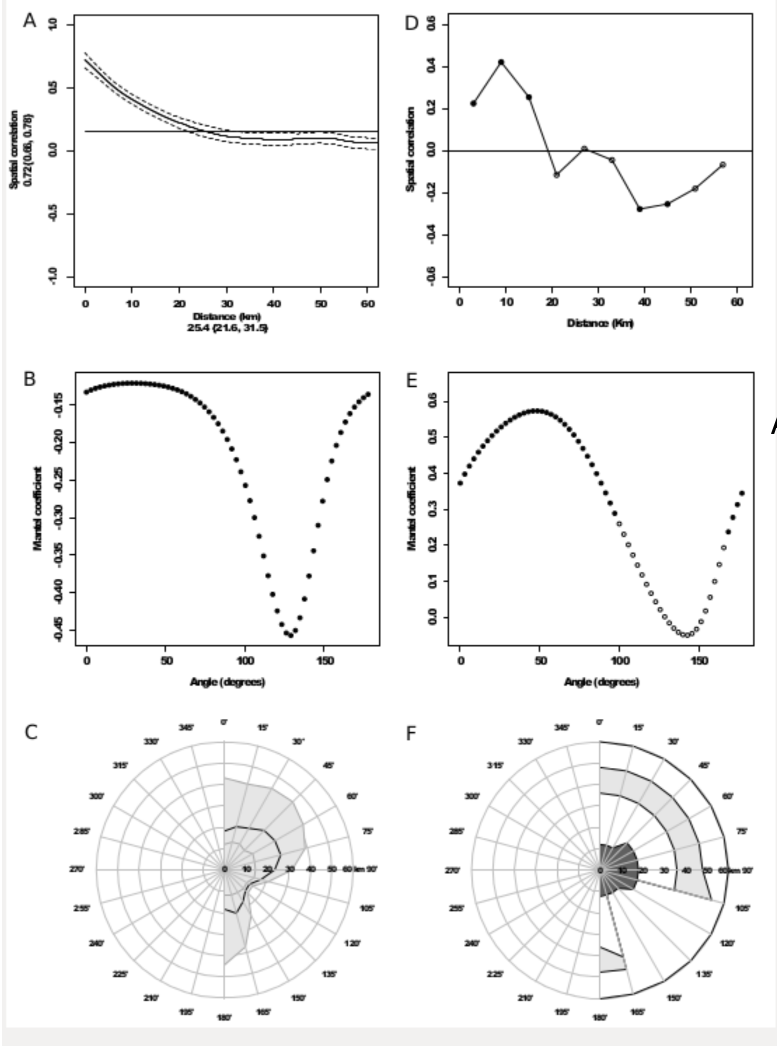
- Dispersal should be weaker in the direction of propagation than along the front of the wave?
- Impact of landscape features on dispersal and sychrony in fluctuations?

Synchrony and genetic spatial patterns

Demography (synchrony) | Genetics (F_{ST})

Isotropy

spatial scale =
25 km (CI $_{95\%}$[21.6-0-31.5])



spatial scale =
18 km

Anisotropy

Angle with the weakest
Mantel r
=
132° from North

Angles with the weakest
Mantel r
=
[100°-165°] from North

Spatial scale =
~14km (CI $_{95\%}$[12.4-15.3])

Direction=
[120°-135°] from North

Spatial scale =
~12km

Direction=
[135°-165°] from North

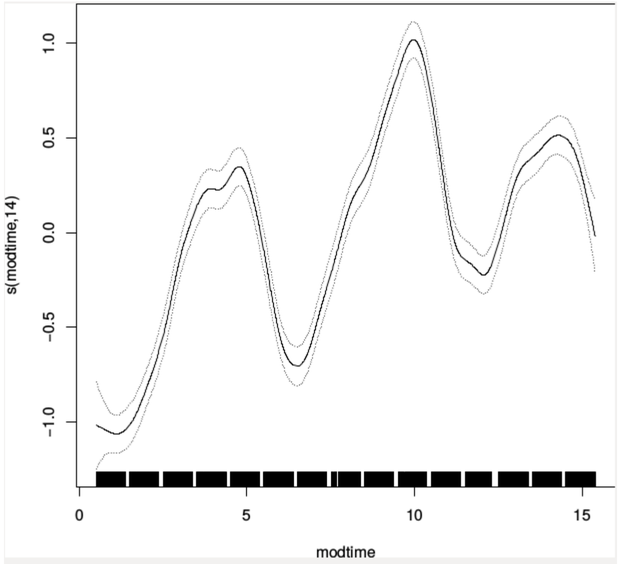
Travelling Wave evidence

TW estimates: General additive models

⇒ Null Model: fluctuations as a function of only time

⇒ TW model: moving in a direction θ from north at a constant speed 1/r

Maximum likelihood estimates (MLE) of θ and r:
⇒ model AIC for 10000 combinations of these parameters



- AIC (TW model / model null = 237)
- MLE for angle (θ) = 135° from North ($CI_{95\%}$[113.2-176.3])
- MLE for speed (1/r) = 7.37 km/year ($CI_{95\%}$[3.88-23.01])

TW emergence and landscape heterogeneity

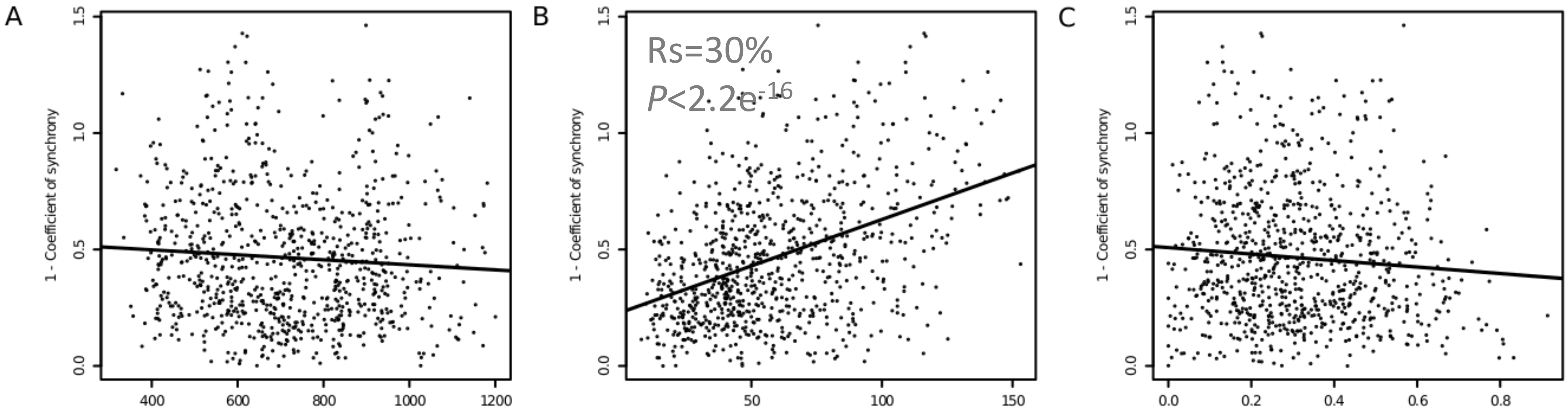
- Gradient in habitat quality => impacts population growth

=> Fossorial water vole: habitat = grassland

- Large-scale obstacle => impacts dispersal

=> Fossorial water vole: barrier to dispersal = sharp elevation (relief)

⇒ Delay in synchrony between each locality and its neighbours impacts : 1-synchrony

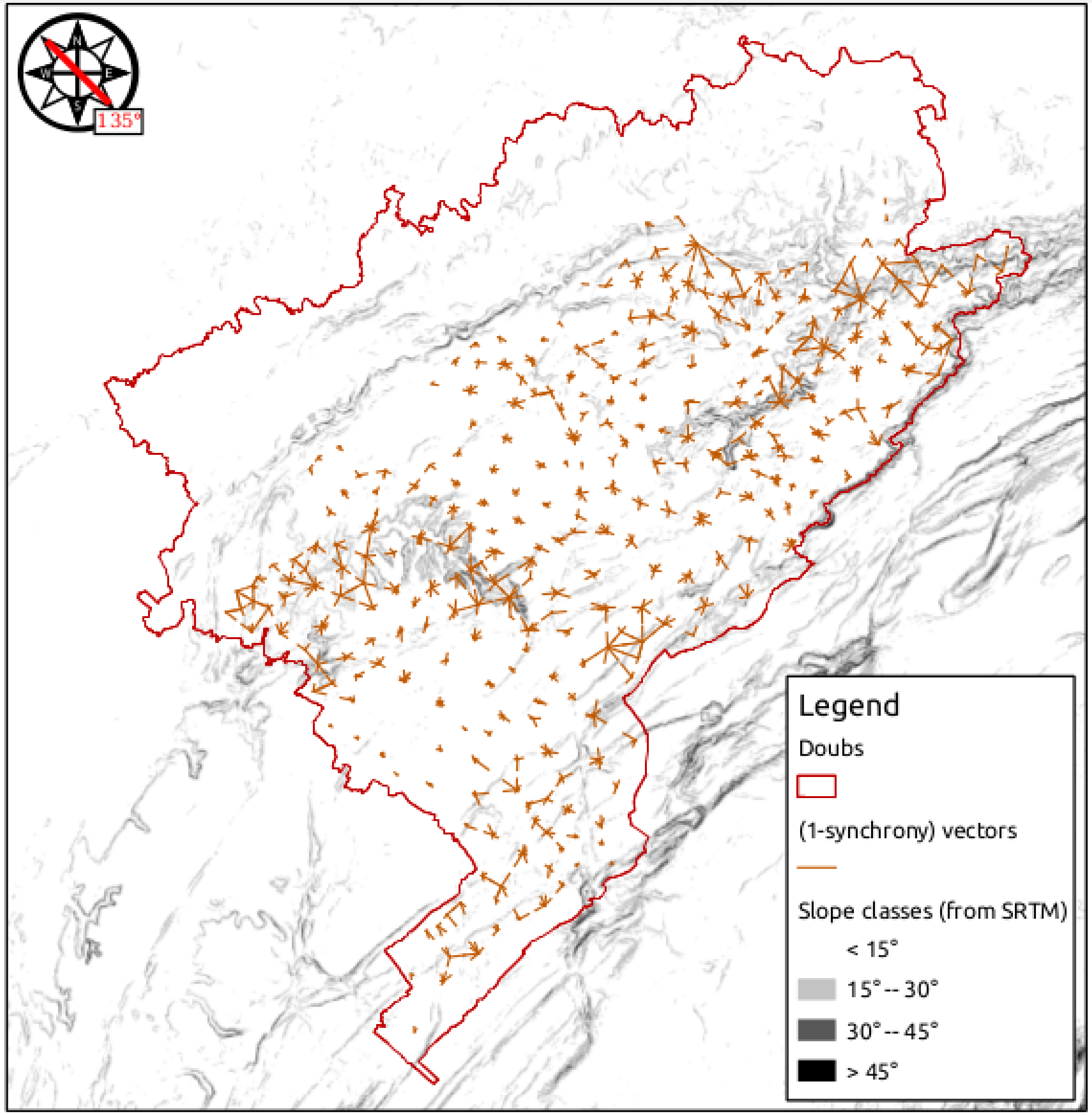


Mean elevation (m) between localities

Elevation slopes (m) between localities

Grassland ratio between localities

TW emergence and landscape heterogeneity



Dispersal, landscape and TW in cyclic voles in the Jura Moutains

⇒ Linear TW spreading from north-west to south-est at a speed of 7-8 km/year

⇒ Demographic and genetics anisotropy: smaller spatial scale of synchrony and gene flow along the propagation axis

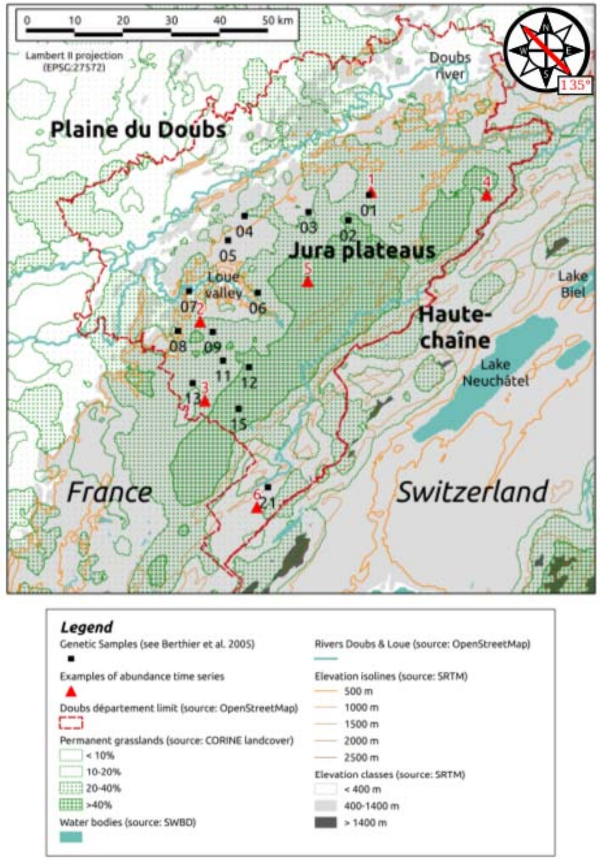
⇒ TW emerges and spreads perpendicular to the edge of the Jura Plateau

- Sharp elevation

⇒ disorganise synchrony & barrier to vole dispersal

- Large-scale obstacle impacting dispersal

TW moving away perpendicular to the obstacle



Among the first emperical evidences matching theoretical expectations:

⇒ Large periodic TW occuring in natural fluctuating populations
⇒ TW emerging and spreading from a large-scale obstacle impeding dispersal

Mapping **A**veraged **P**airwise **I**nformation

a new exploratory tool to analyse population spatial structure

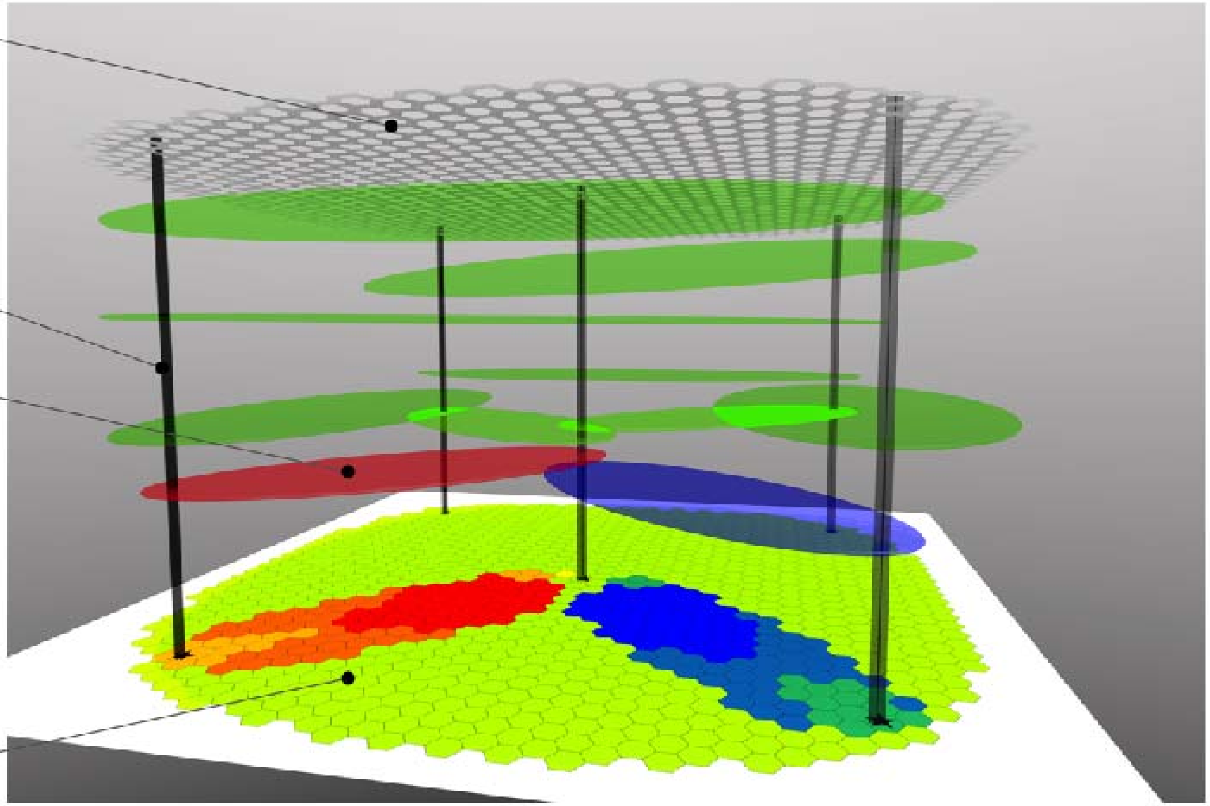
Principle

Initial grid

Sample

Ellipse

Ellipses contains the value of the genetic distance between two samples, on any other pairwise metrics

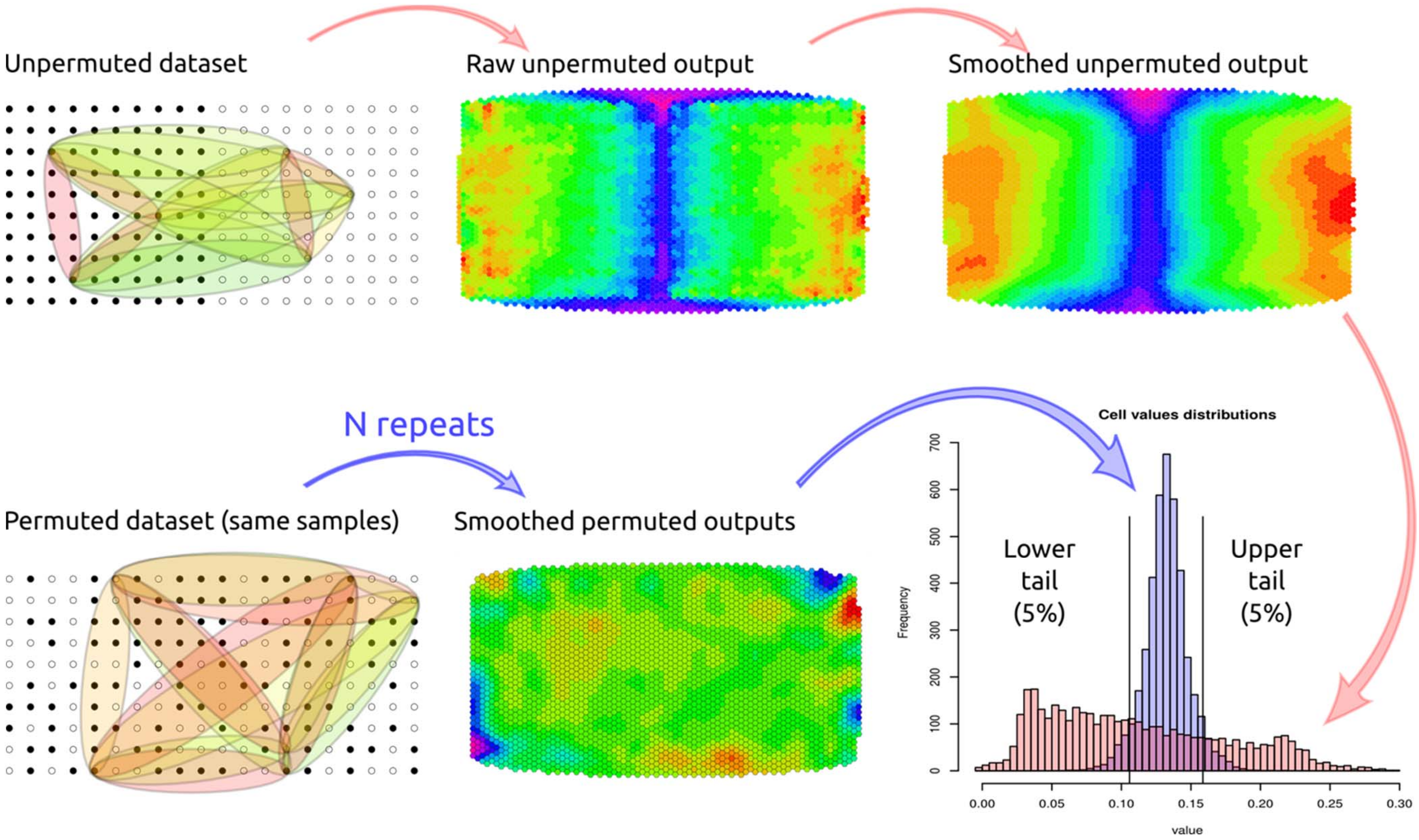


Result grid

1 cell = weighted mean of metrics associated to ellipses crossing above the cell (weight = inverse of ellipse area)

Mapping **A**veraged **P**airwise **I**nformation

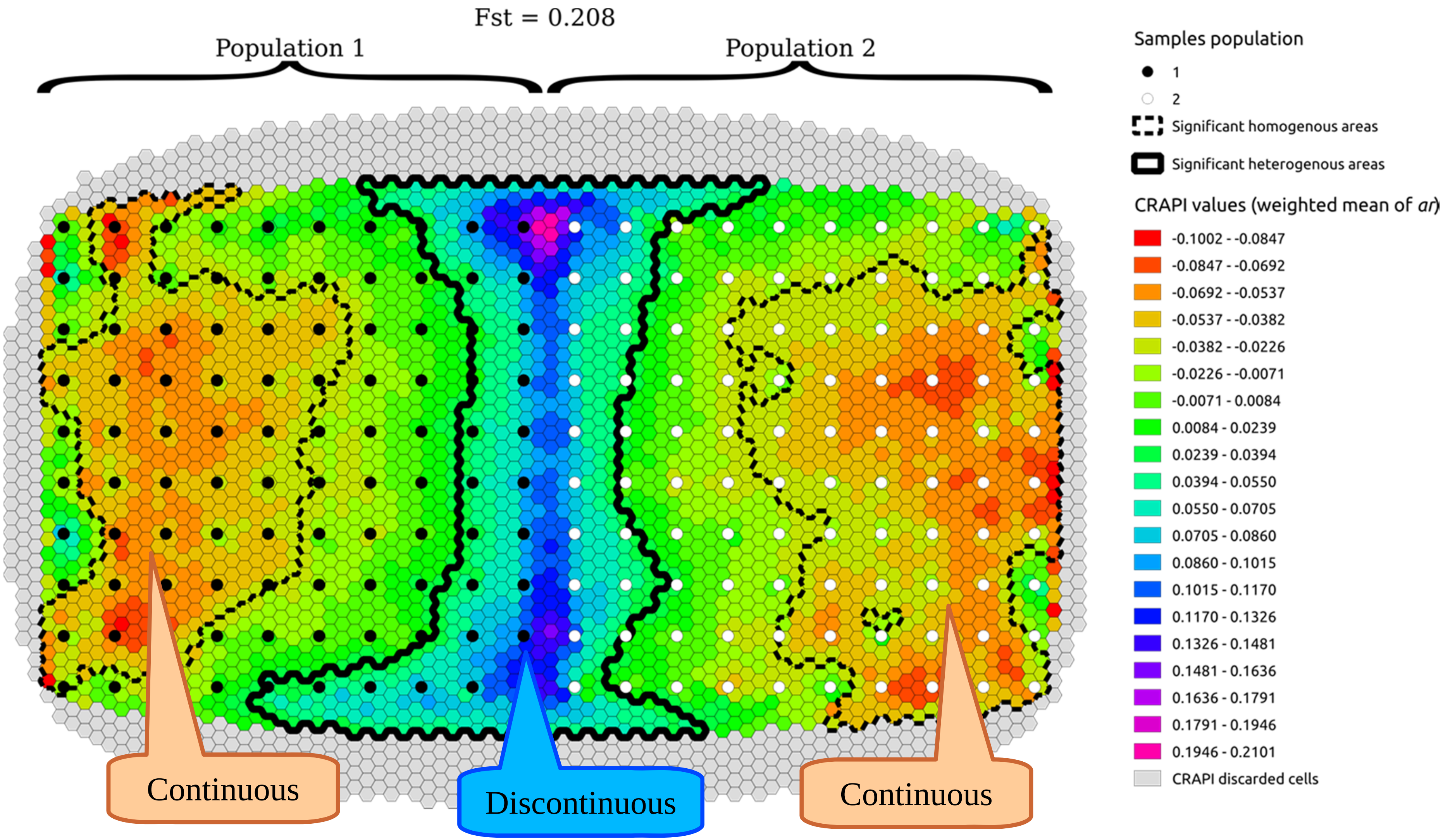
a new exploratory tool to analyse population spatial structure



Mapping Averaged Pairwise Information

a new exploratory tool to analyse population spatial structure

Interpretation



Mapping **A**veraged **P**airwise **I**nformation
&
Vole Travelling Waves in the Jura Moutains

Synchrony between all pairs of localities

Synchrony between adjacent pairs of localities