Spatiotemporal Evolution of Cattle Movement Network in France

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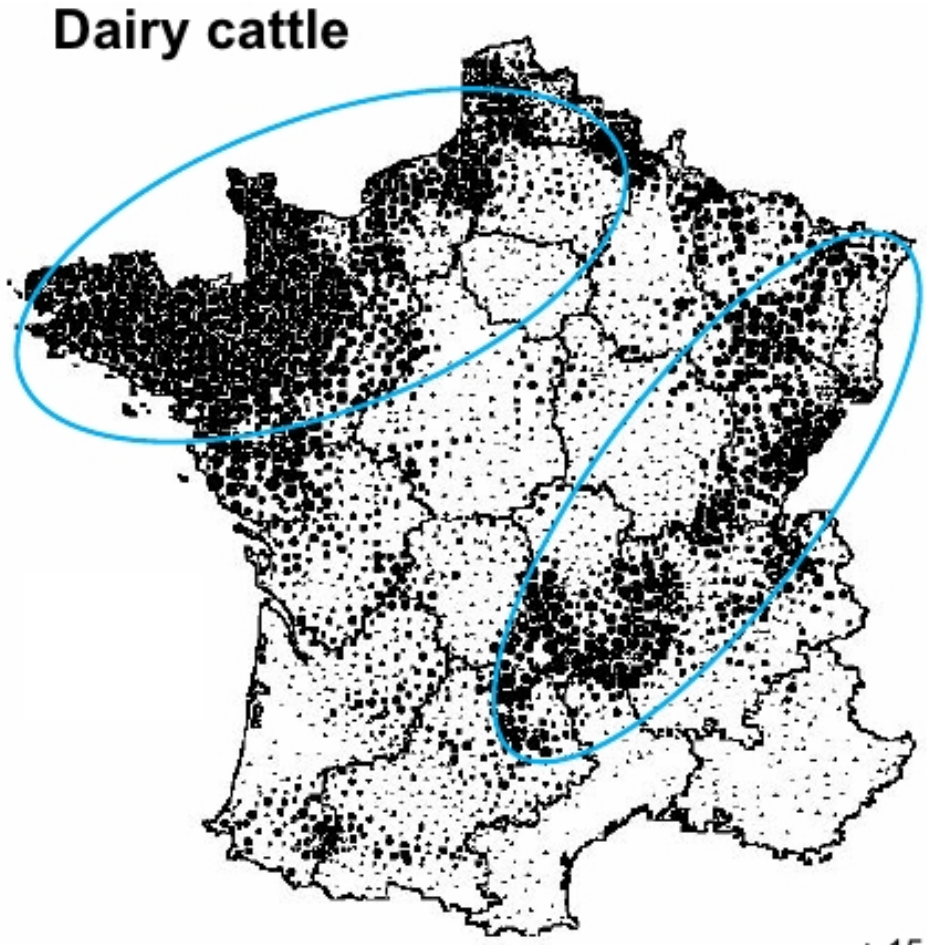
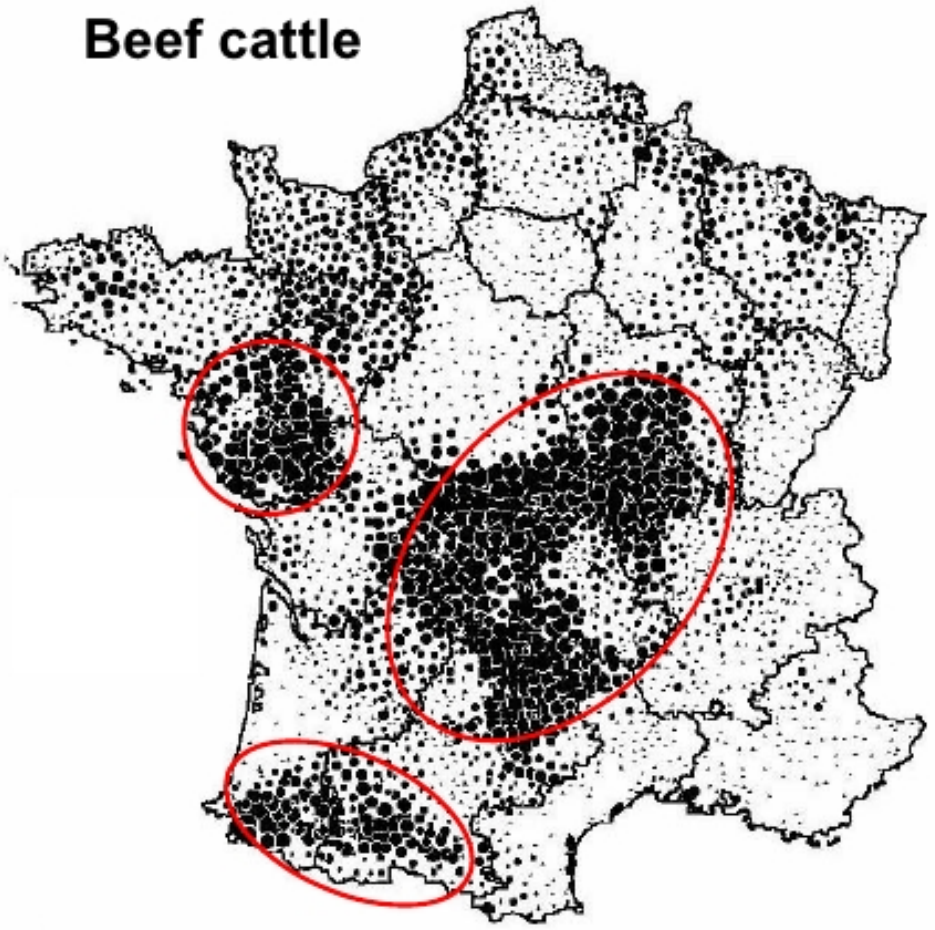
Background : The distribution of cattle in France



11 breeds under selection programs

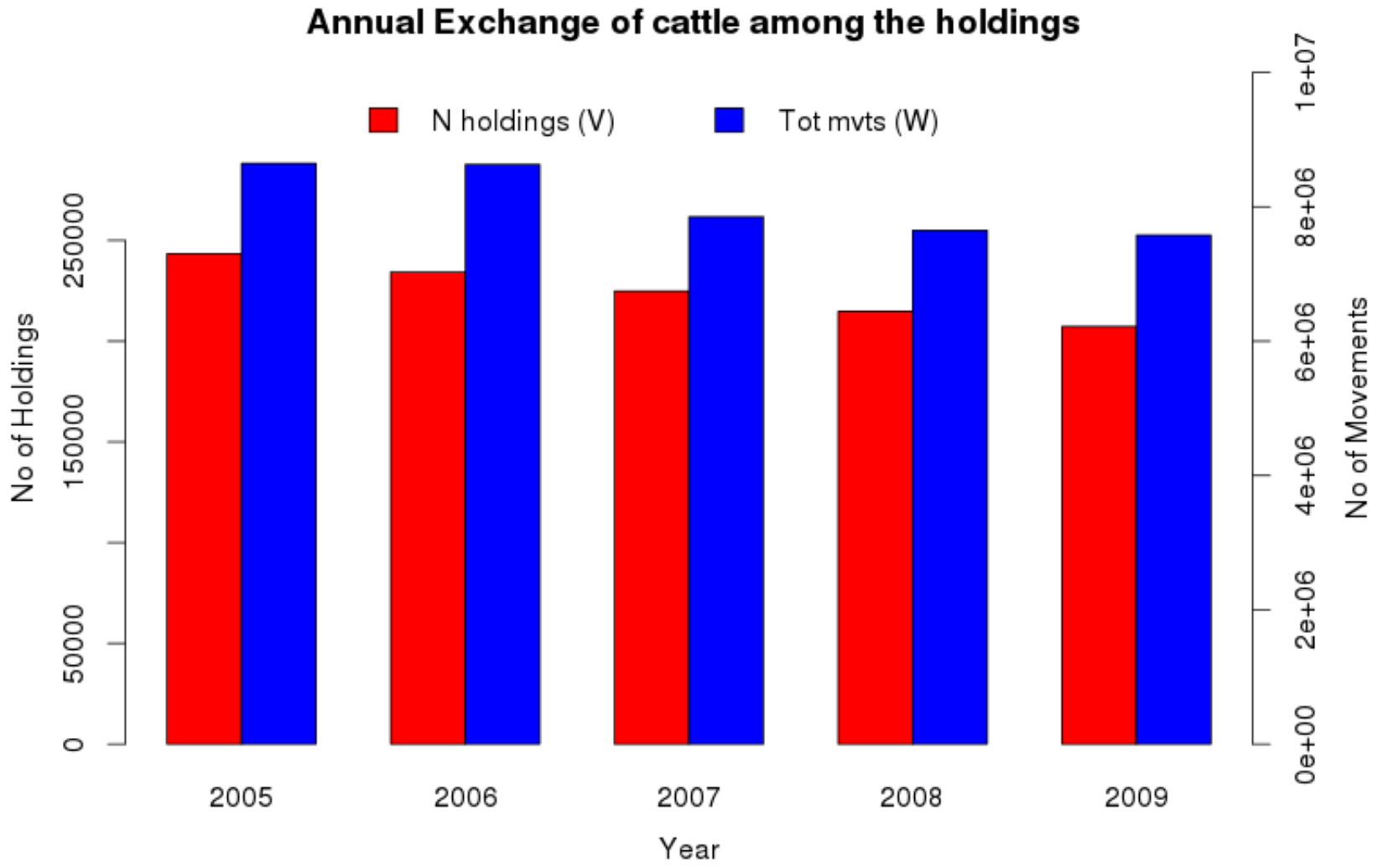
+ 15 breeds under conservation programs

ICAR 2011



9 breeds under selection programs (incl. 3 hardy breeds)

Source: Institut de l'Elevage



Holding ≡ {Farm, Market, Assembling centre}

Data source: La Base de Données Nationale d'Identification des bovins (BDNI)

Objectives

The animal exchange network

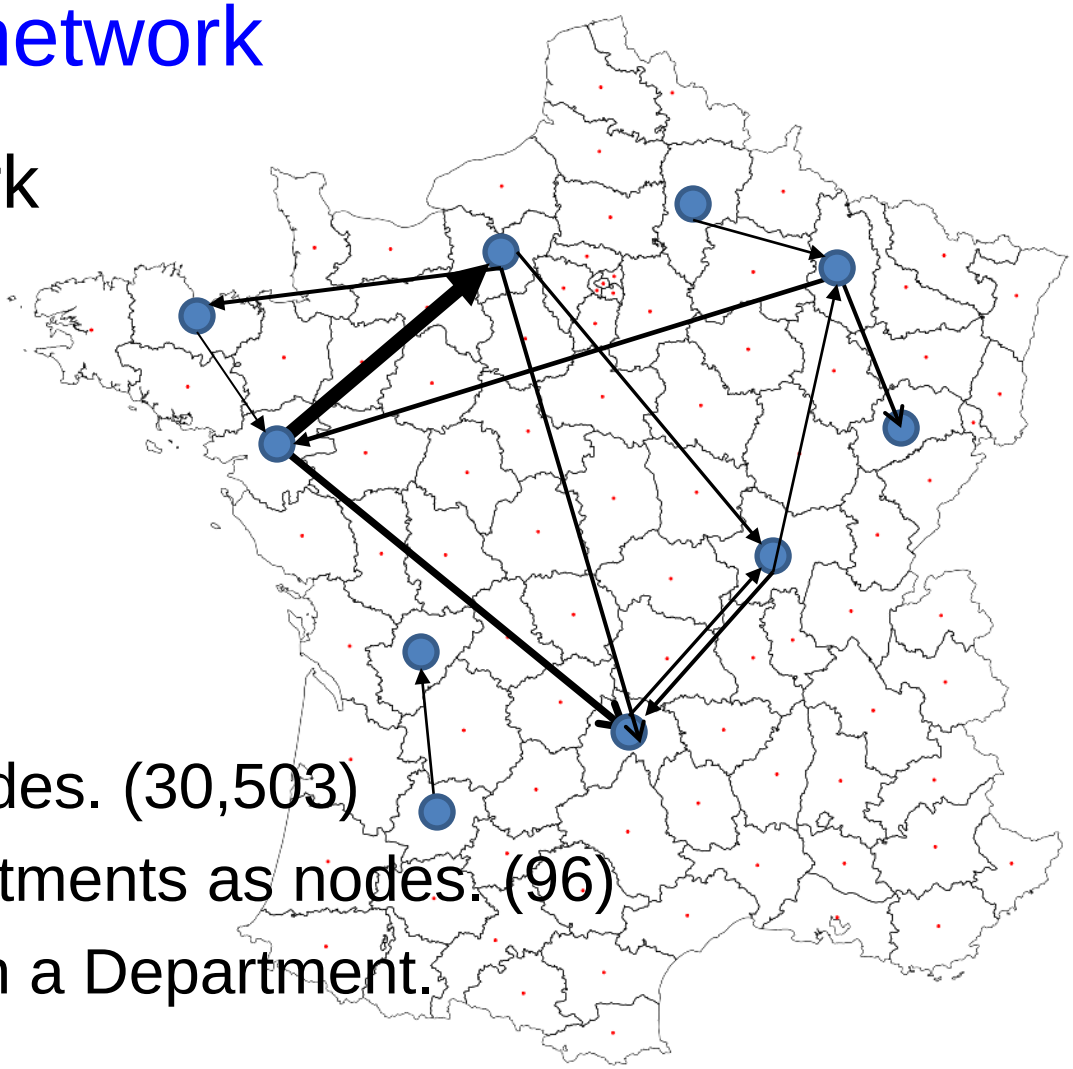
- a basis for epidemic process

- Characteristics of the network.
- Its time evolution (different temporal and spatial scales).
- Case study: network in the light of an event of movement restrictions
  - Bluetongue fever outbreak in France in 2007-08.
  - Which network descriptors were affected (if any).

The network

- Weighted directed network

Weight ≡ no of movements



Spatial organization:

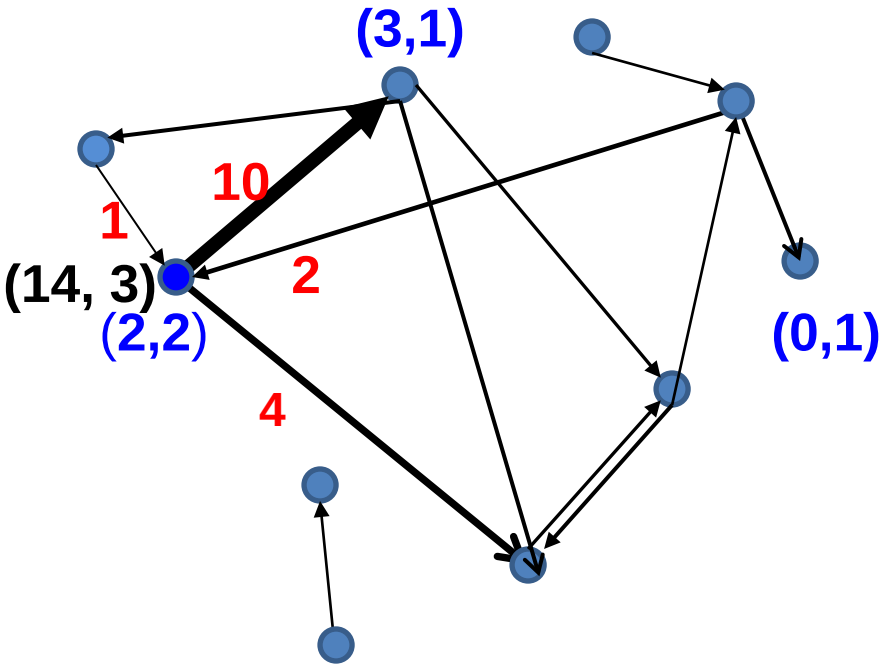
- Layer 1: Holdings as nodes.
- Layer 2: Municipalities as nodes. (30,503)
- Layer 3: Administrative Departments as nodes. (96)
- Layer 4: Layers 1 and 2 within a Department.

Temporal organization:

- Level 1: Annual time window accumulation. (5)
- Level 2: Time window of 4 weeks. (65)
- Level 3: Weekly networks. (260)

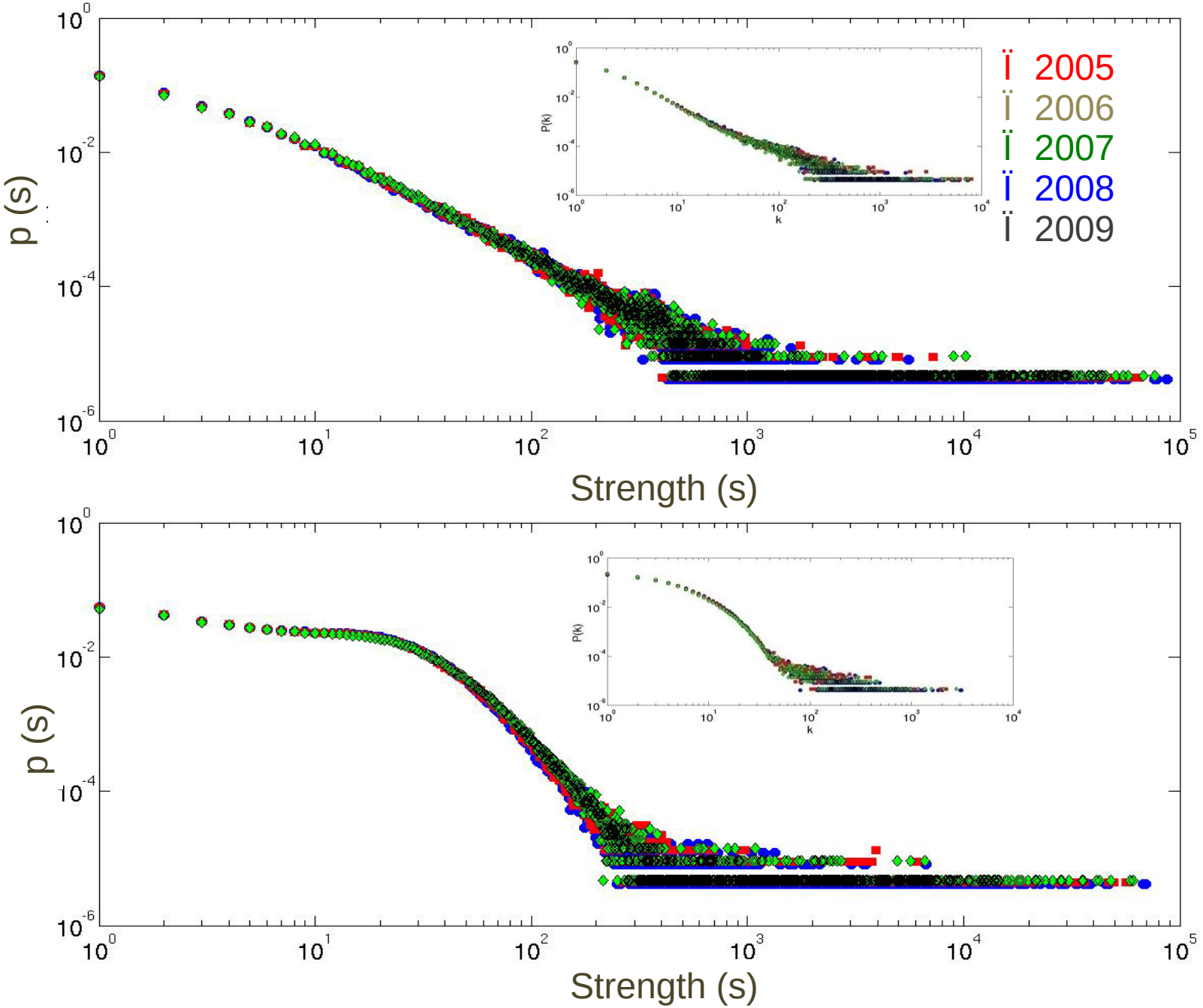
Observations

Degree: number of holdings a holding is connected to (out) / from (in).



Strength: number of movements from a holding (out) / into a holding (in).

Distributions of strength and degree for annual networks



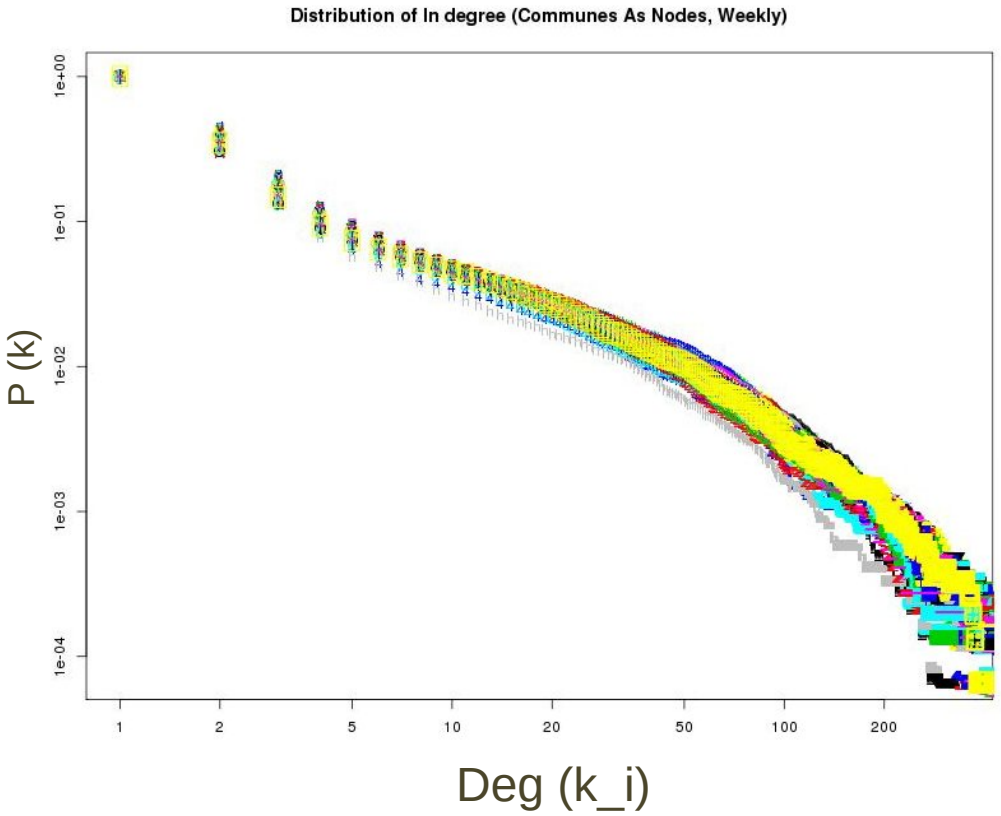
In-strength (in- degree) Distribution PL Exponet 1.7 (1.8)

Out-strength (out- degree) Distribution PL Exponent 1.5 (1.5)

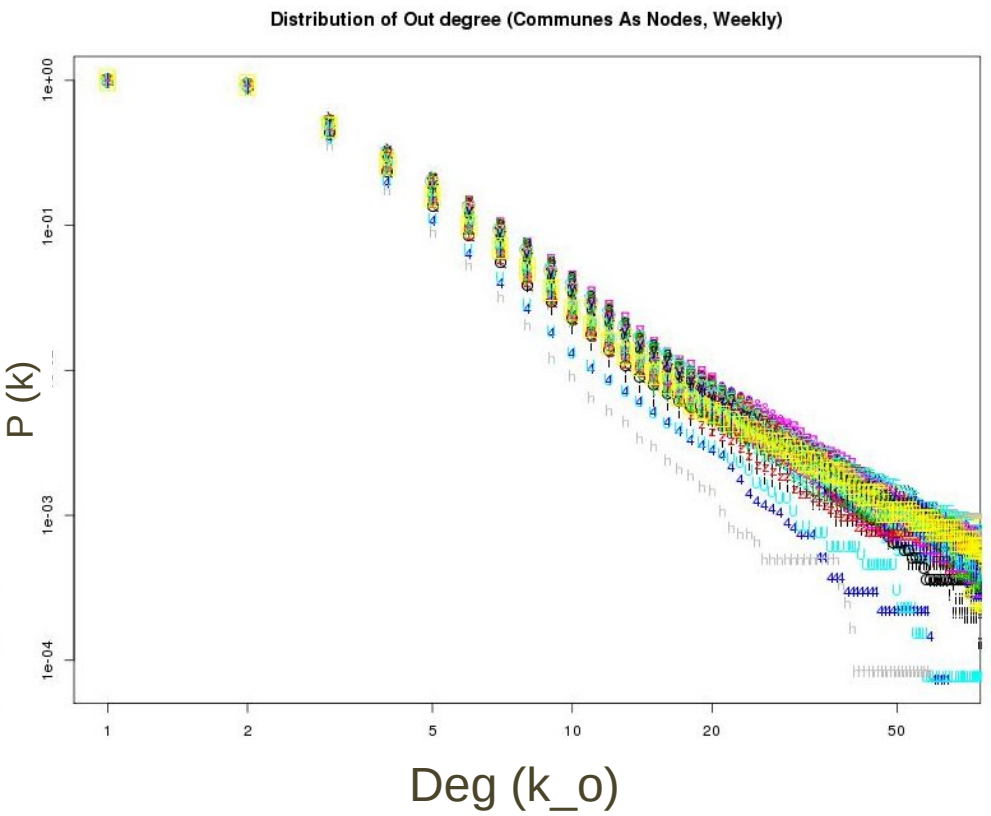
Yearly distributions are not significantly different. Same in other two time windows.

Cumulative distributions for weekly aggregated networks with municipalities as nodes.

in-degree

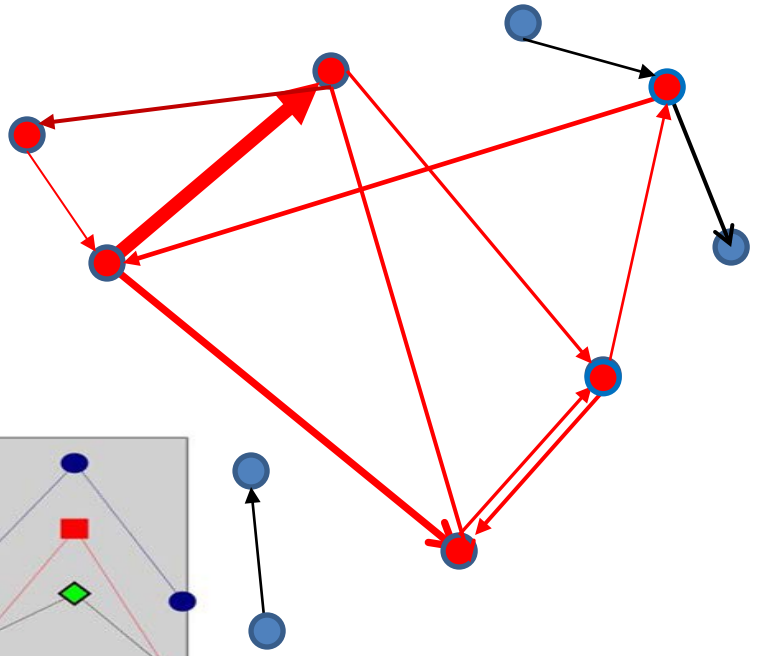


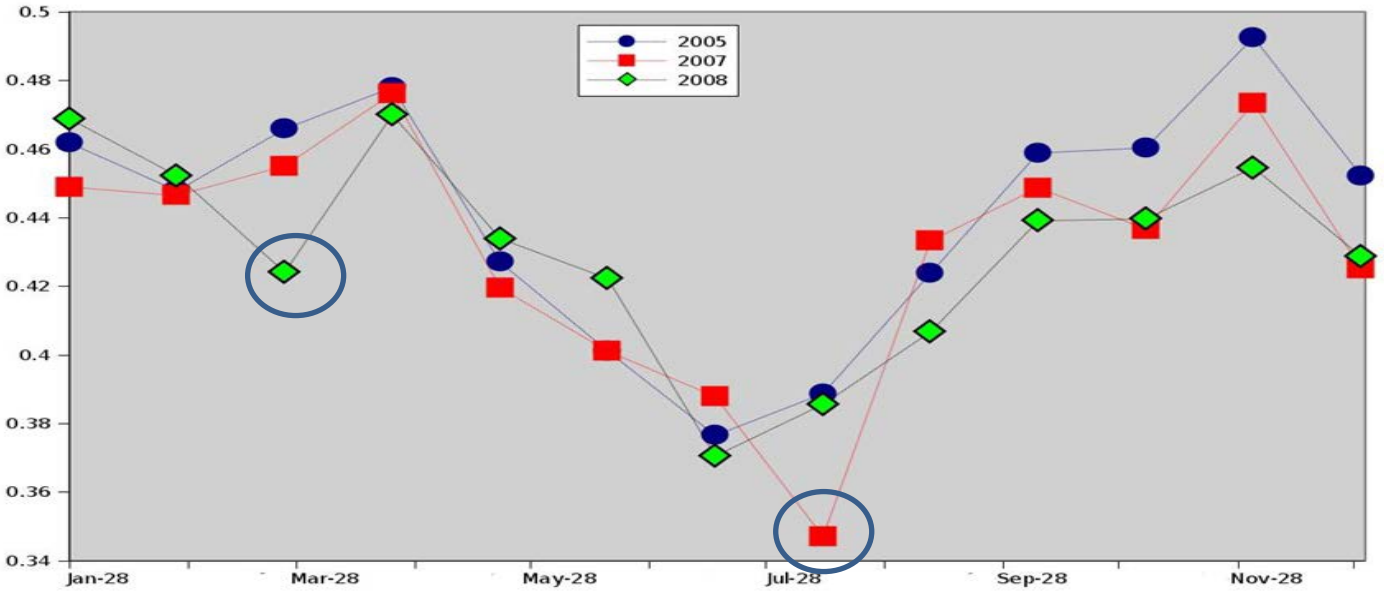
out-degree



Some differences at smaller time windows and/or accumulated nodes

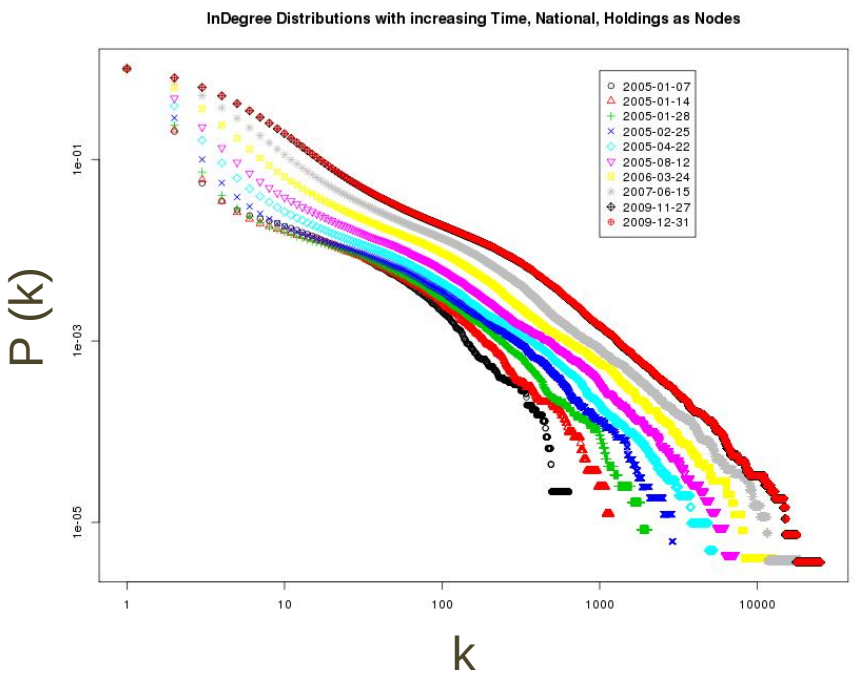
Giant Strongly Connected Component (GSCC): The largest sub network where every node can be reached from every other node.

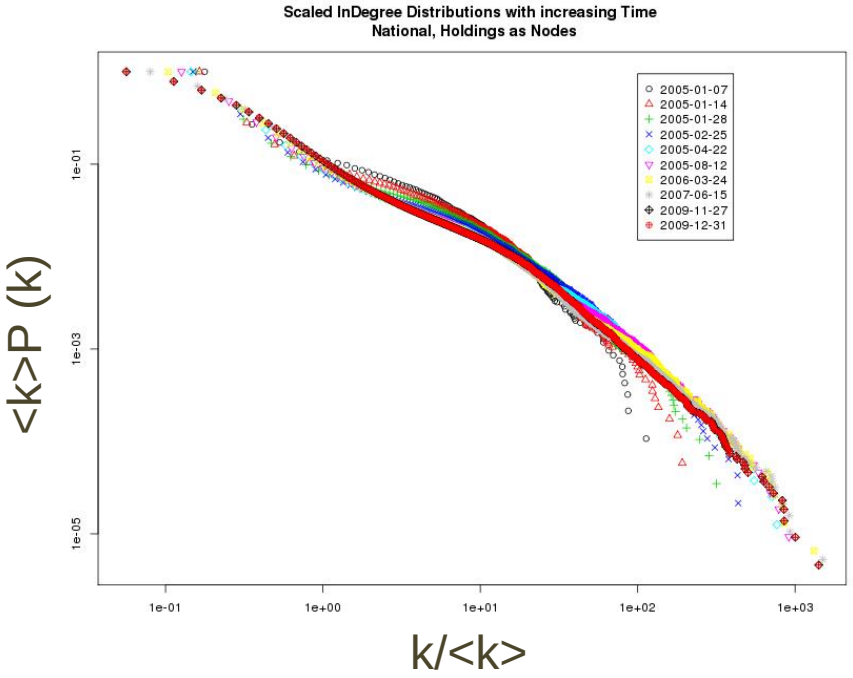




(Normalized) monthly GSCC Size.

Variation of network descriptors on the size of aggregation time-window

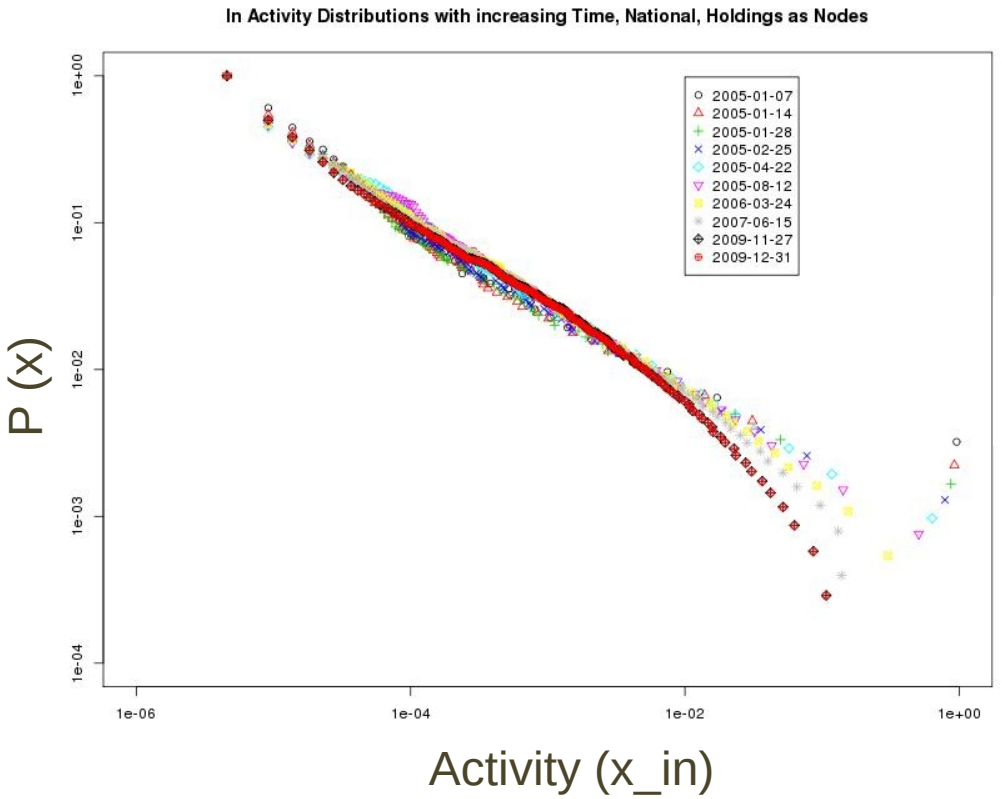


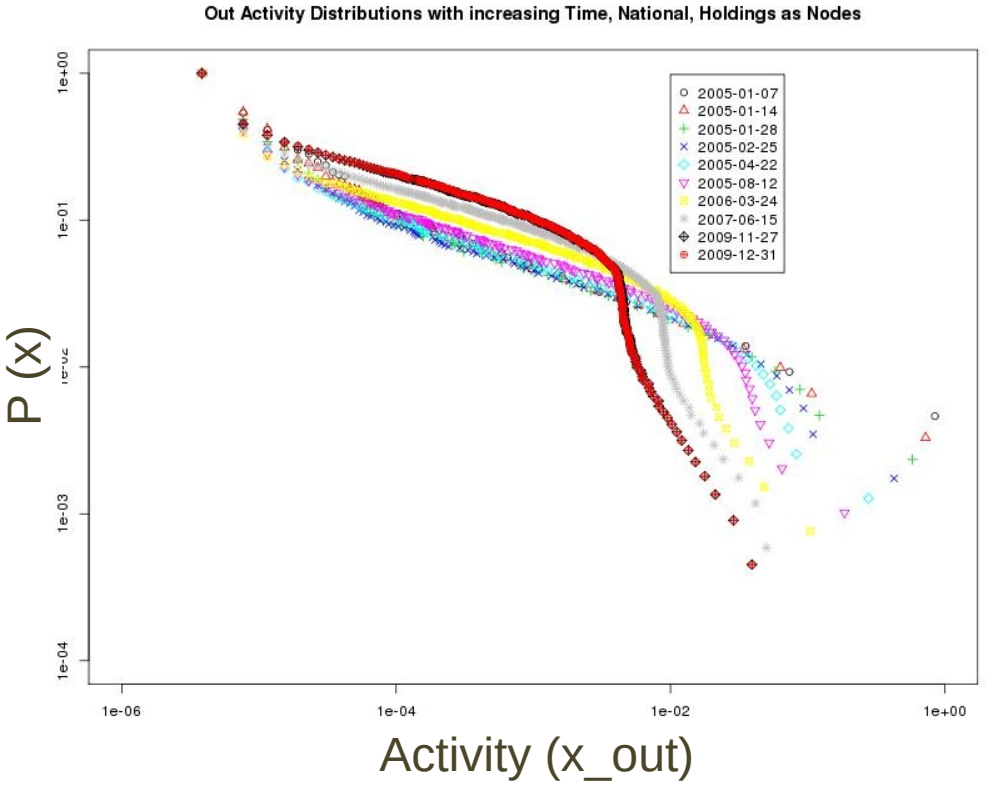


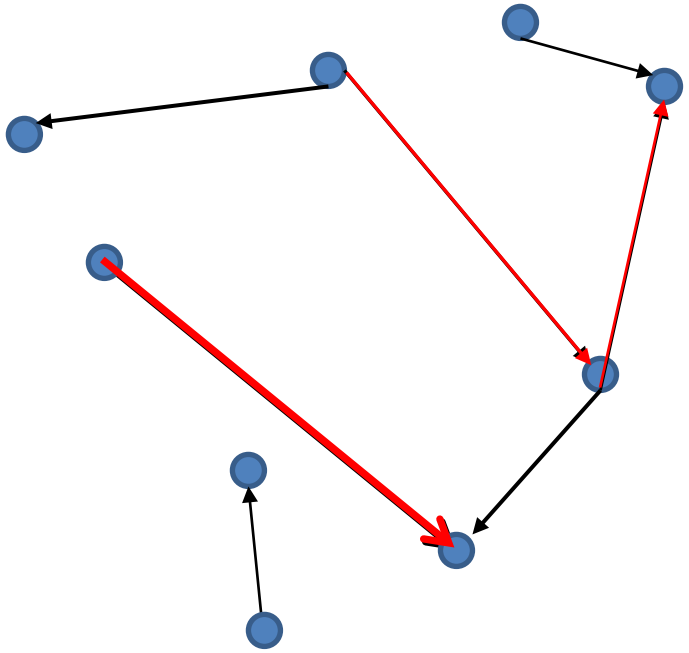
Rescaling ' time window independence of the descriptor.

Activity of node *j* **(**in a particular time window Δt **)**:

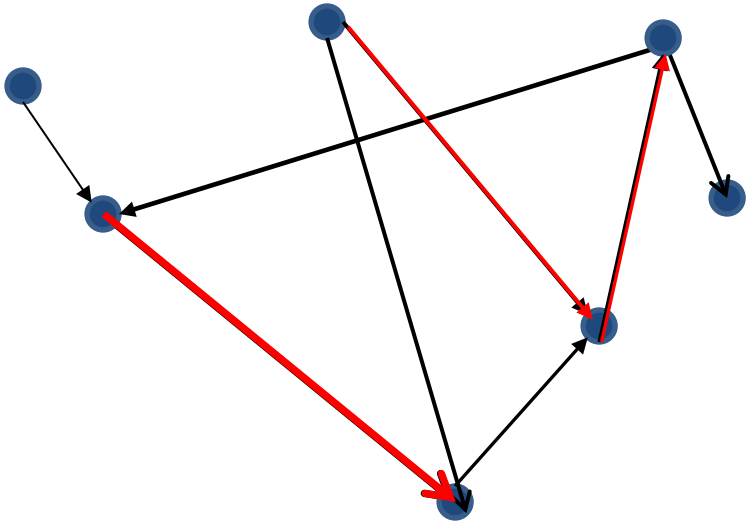
x_j = *ratio of* the number of interactions it performs to the total number of interactions performed by all nodes





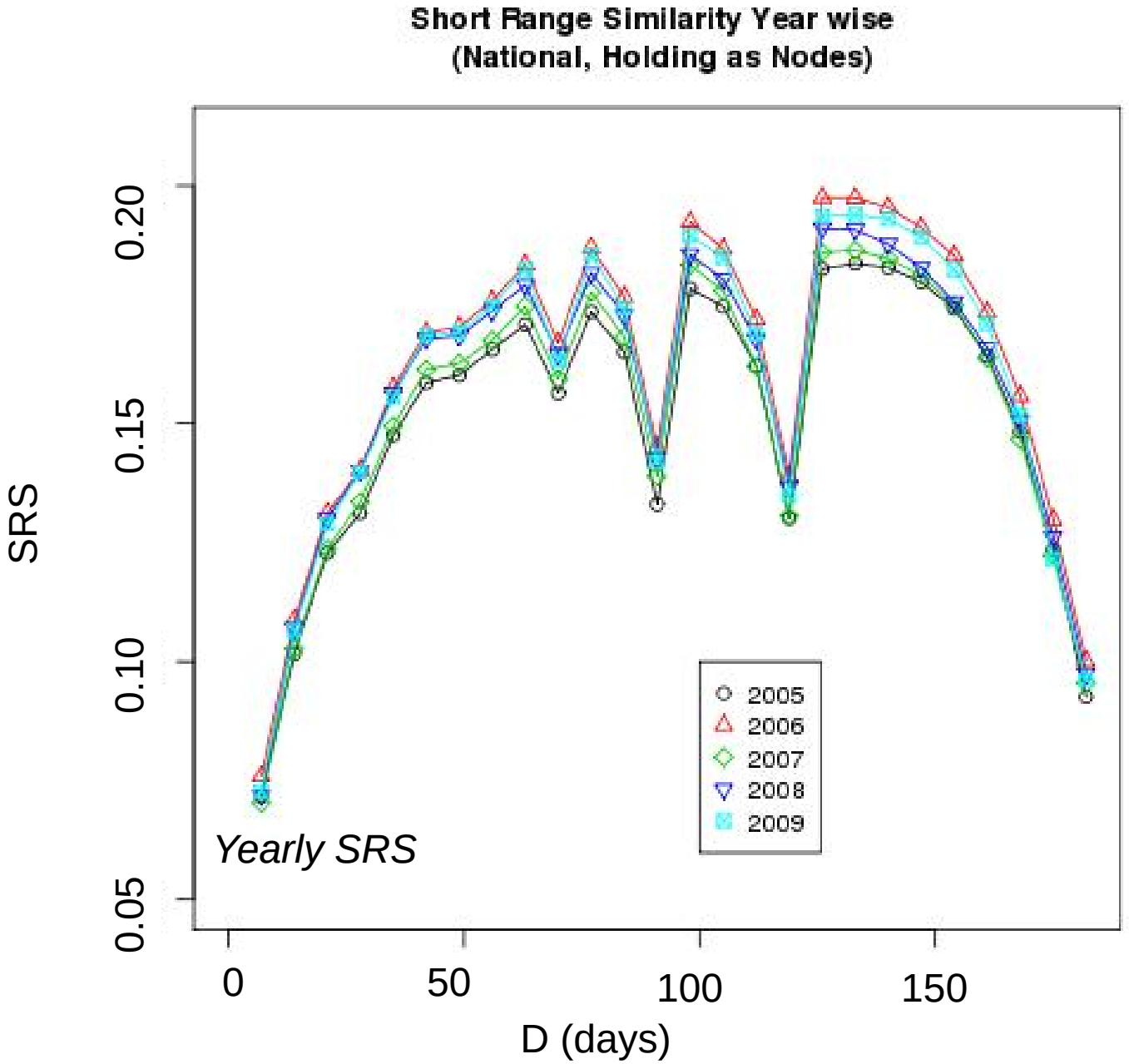


D1



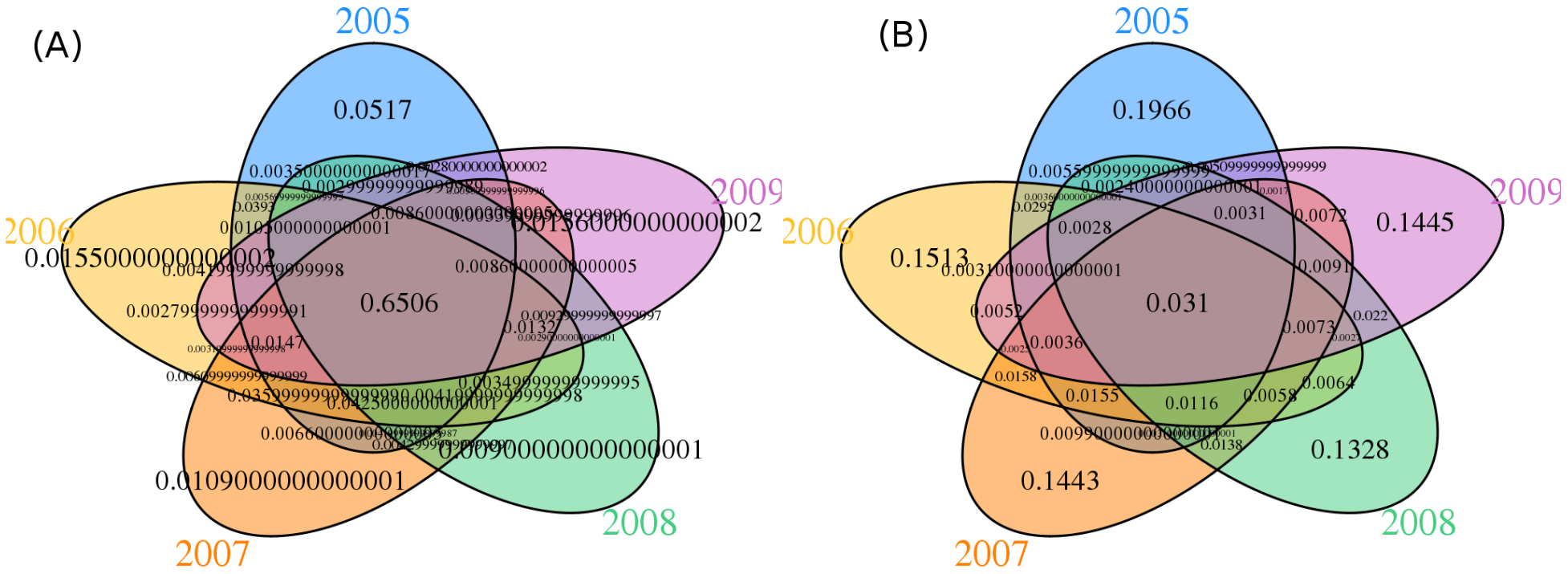
D2

Short Range Similarity (SRS): average fraction of links common to two consecutive aggregation windows.



- Low SRS
- Indifference among the years

Finding a common-backbone



(A) Active common-nodes 2005-2009 ’ ~65% of the total holdings.

(B) Active common-arcs ’ ~0.3% pairs

Conclusions:

Heavy tailed distribution of degree and strength
’ resilience to random node removal.

Evolution over time is robust (topologically).
’ But SRS is very low.

No significant differences in basic descriptive parameters (between and after the movement restrictions.)

A few observed instantaneous differences/changes
’ pushed back to •normal• very soon.

Study on measures of distributional similarities from a dynamical/temporal network point is underway.

Thank you

http://www6.inra.fr/mihmes

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