Hospital network

Health trajectories in California

HCUP Database

90M admissions in both emergency and inpatient departments

ICD-9 diagnoses available for all visits

Unique patient identifier for 76% of data

Health trajectories of 10M patients

Location, size and specialization of 430 Californian hospitals

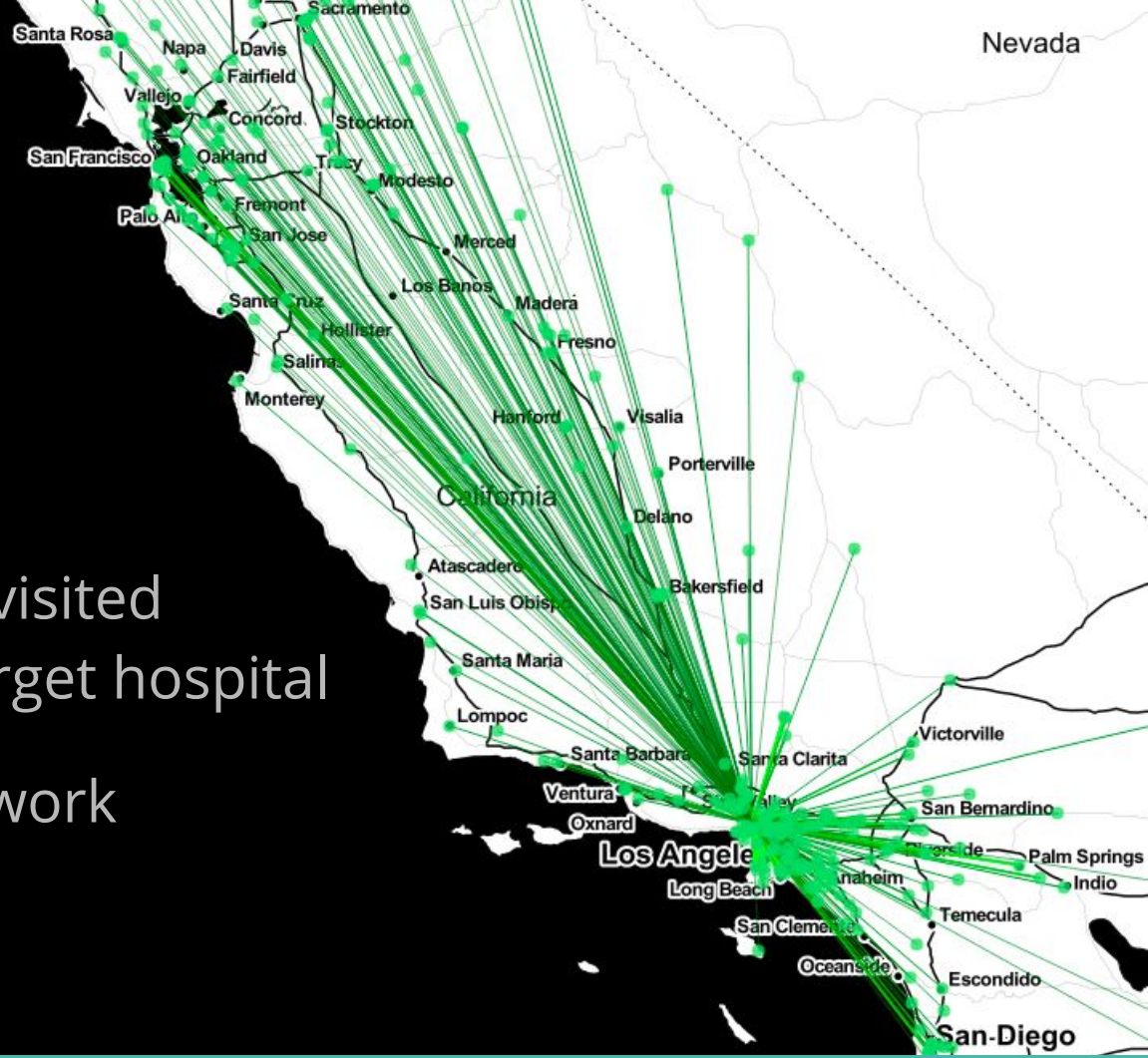
Questions?

How can mobility between hospitals be described?

Can the migration be explained by geography and demography?

What is the impact of hospitals' specialization on mobility?

Measure of health mobility between hospitals



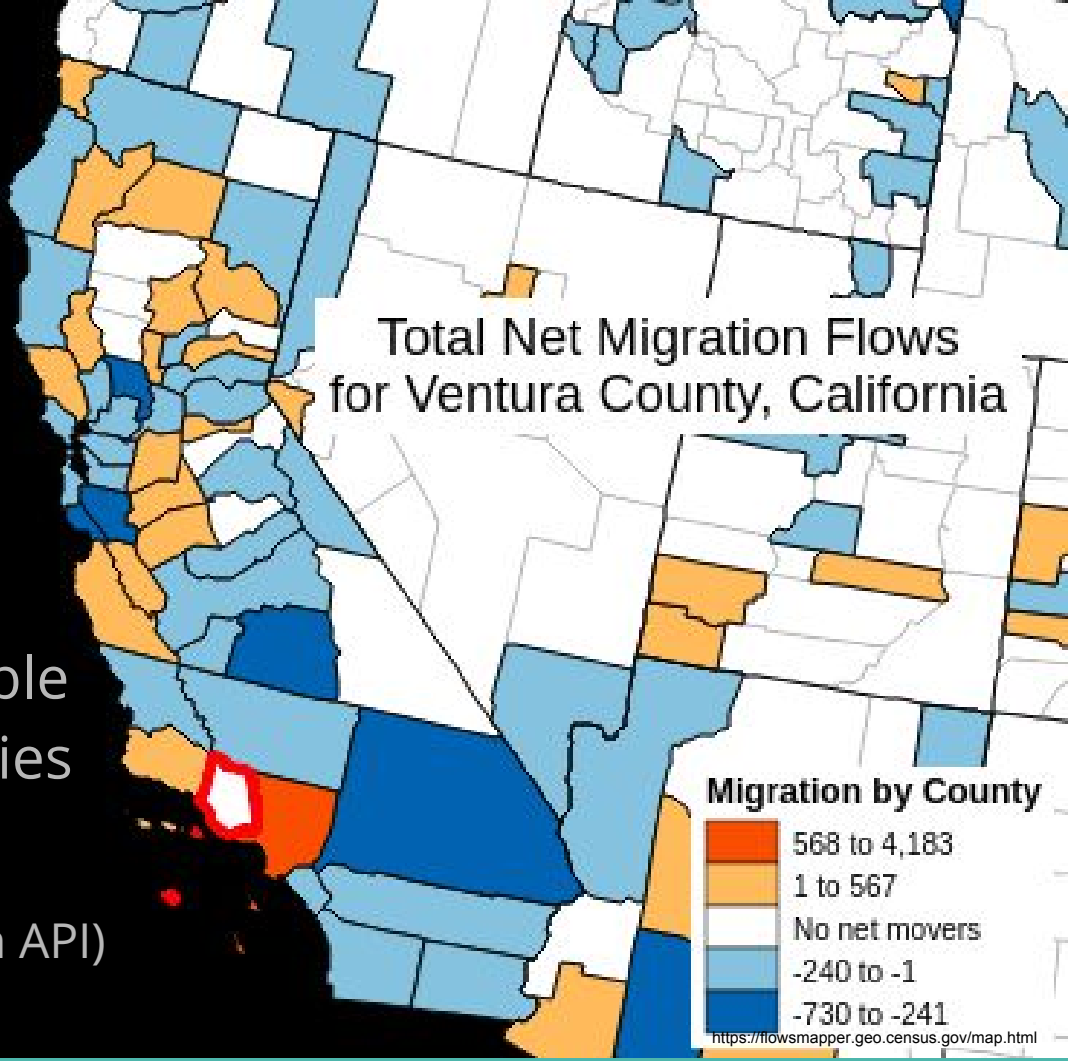
Number of patients who visited source hospital before target hospital

⇒ Directed weighted network

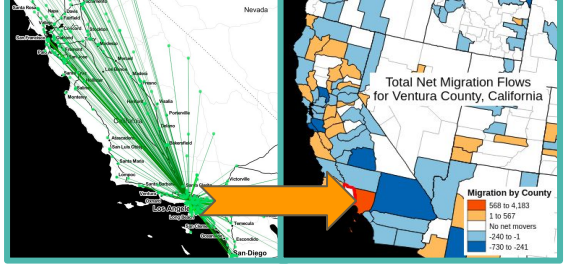
Aggregation by county

430 hospitals → 58 counties
Census migration data available
Flows between pairs of counties

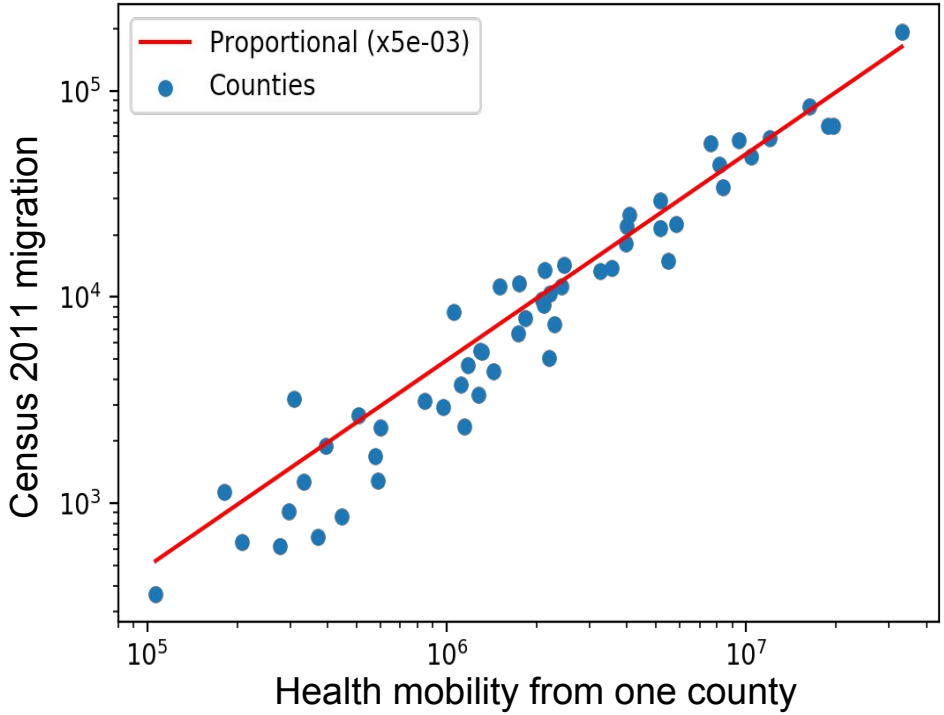
Geographic distance (Nominatim)
Driving distance and time (here.com API)



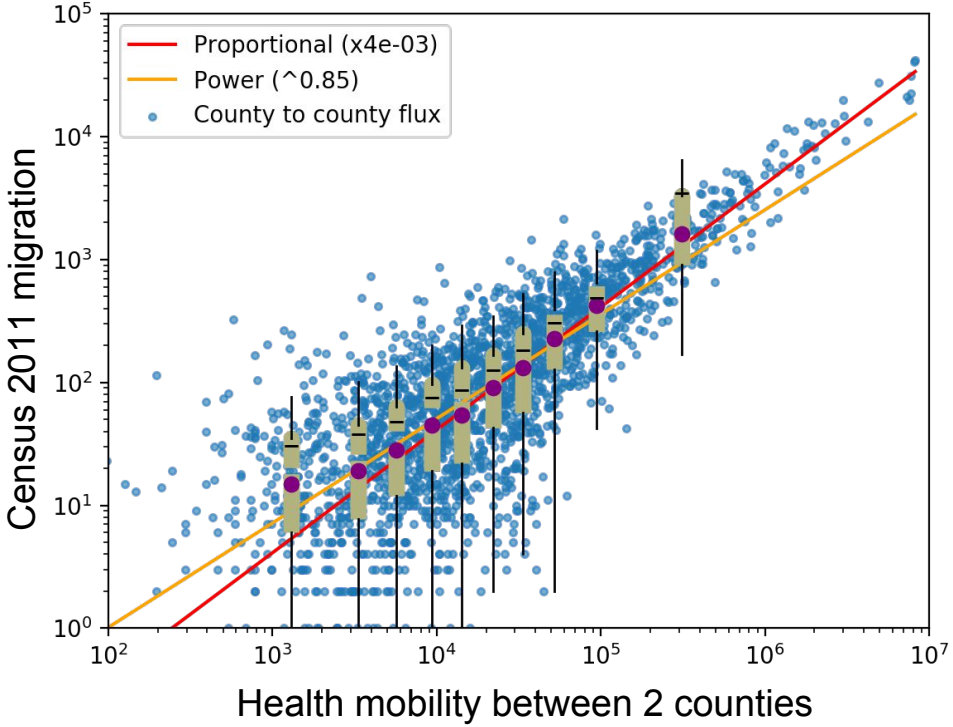
Let's build the counties-network



Migration out of counties (degrees)

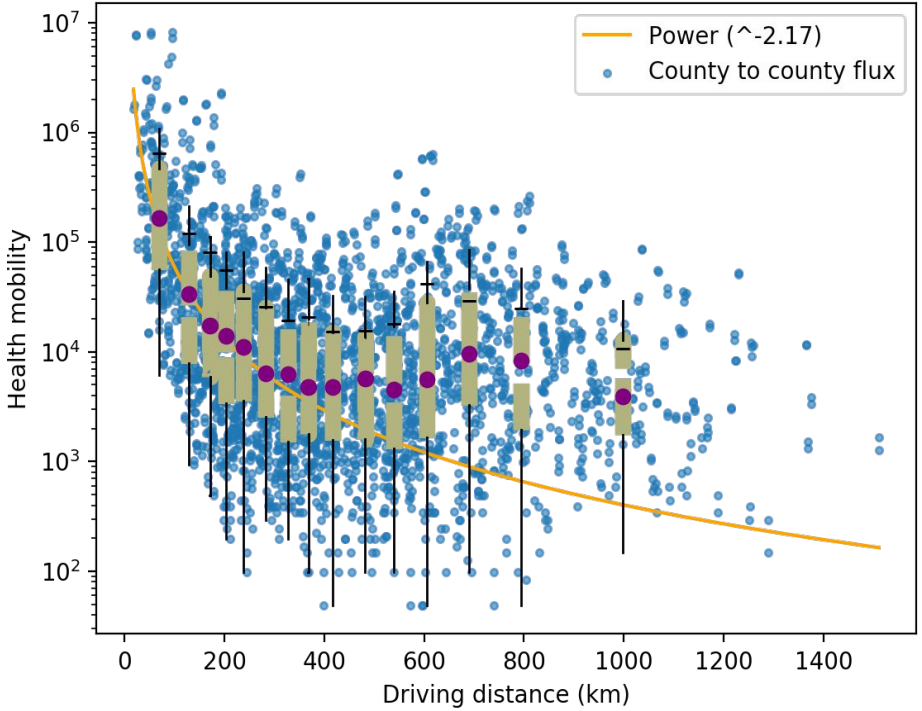


County to county mobility (weights)



Role of geography

Health mobility wrt driving distance



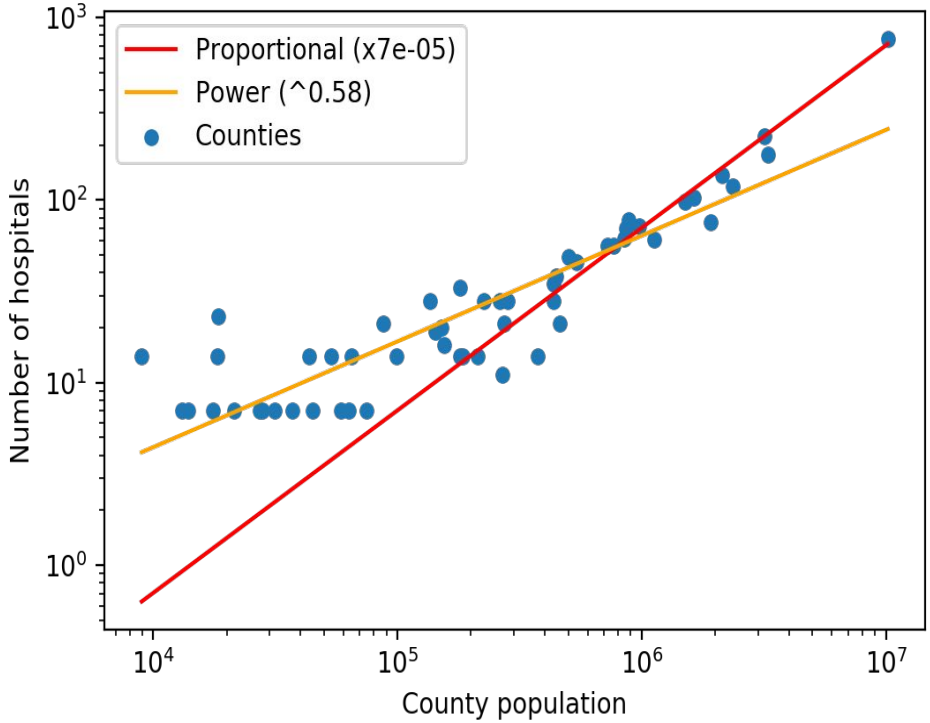
Fits power law for small distances
Strange behaviour for long distances
Geography cannot explain this

Need for demographic models
⇒ Radiation model

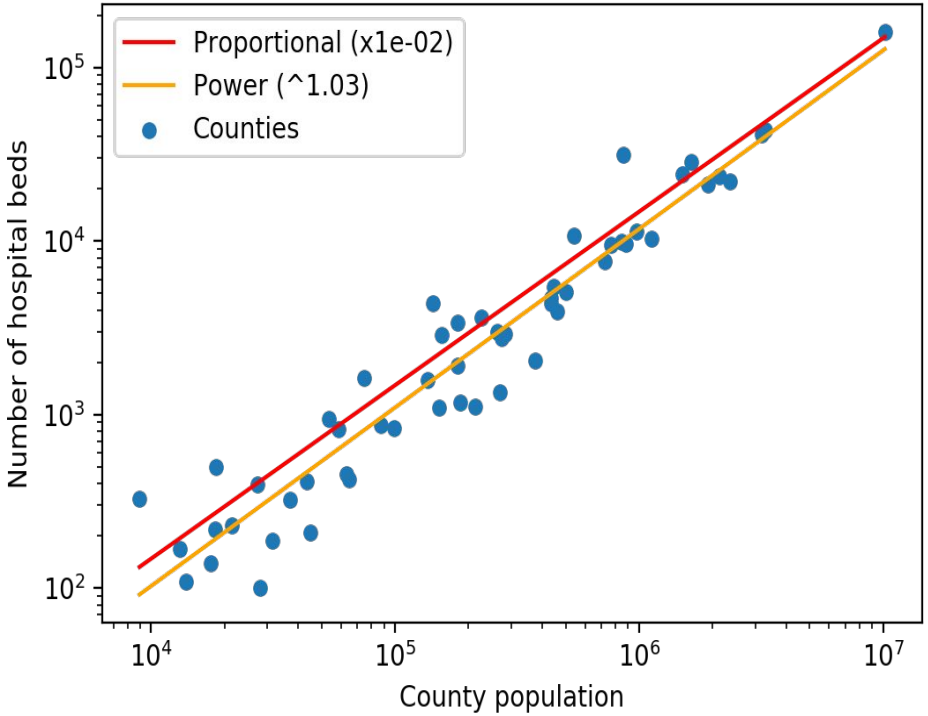
A universal model for mobility and migration patterns
Filippo Simini, Marta C. González, Amos Maritan & Albert-László Barabási
Nature **484**, 96–100 (05 April 2012)

What variable can we use?

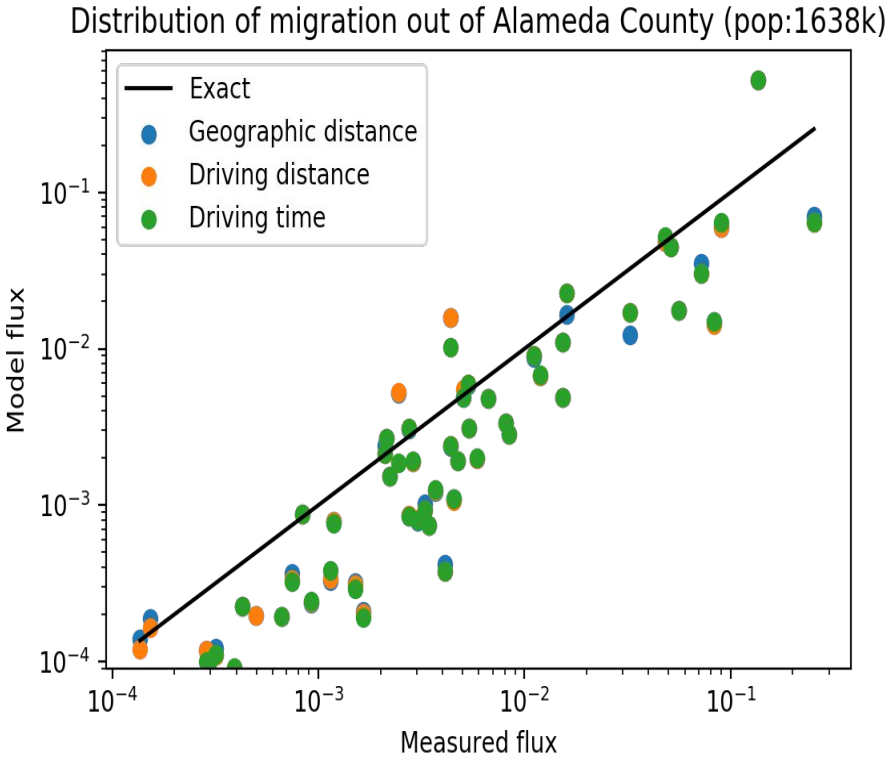
Hospitals per capita

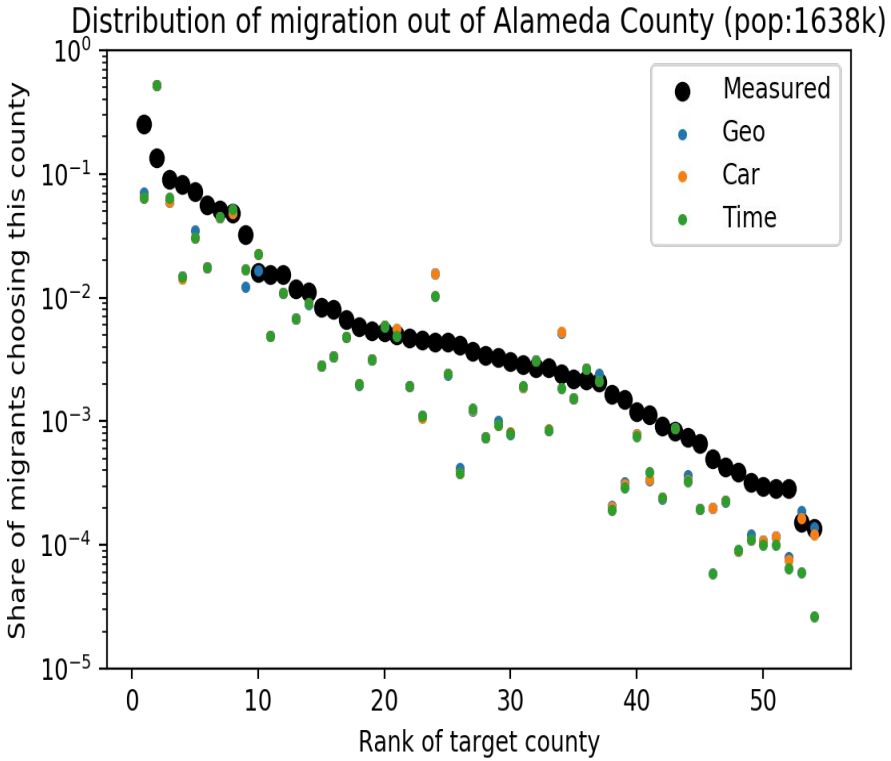


Hospital beds per capita

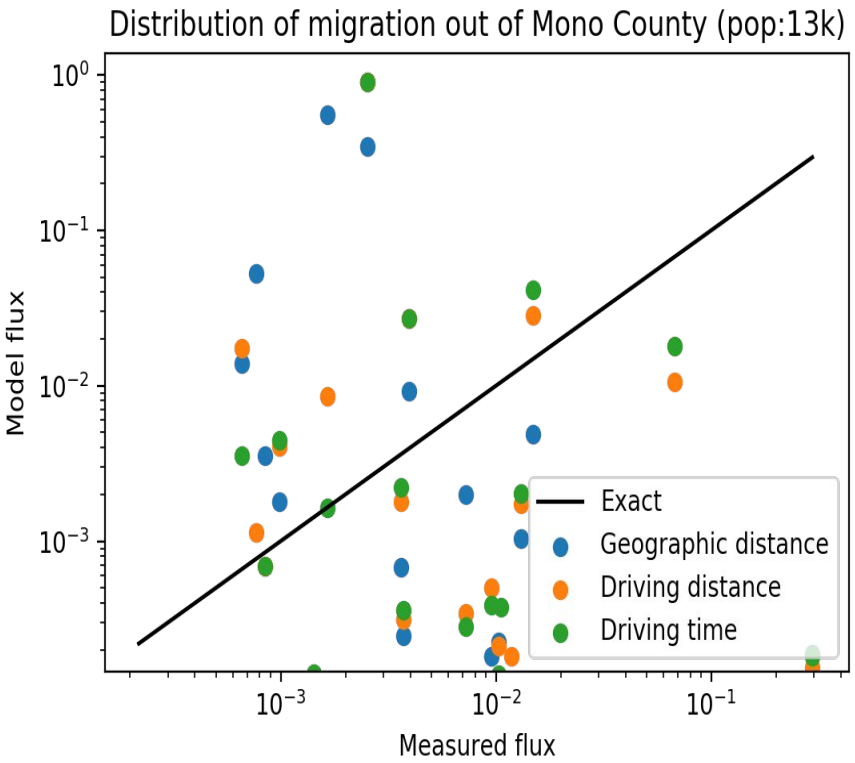


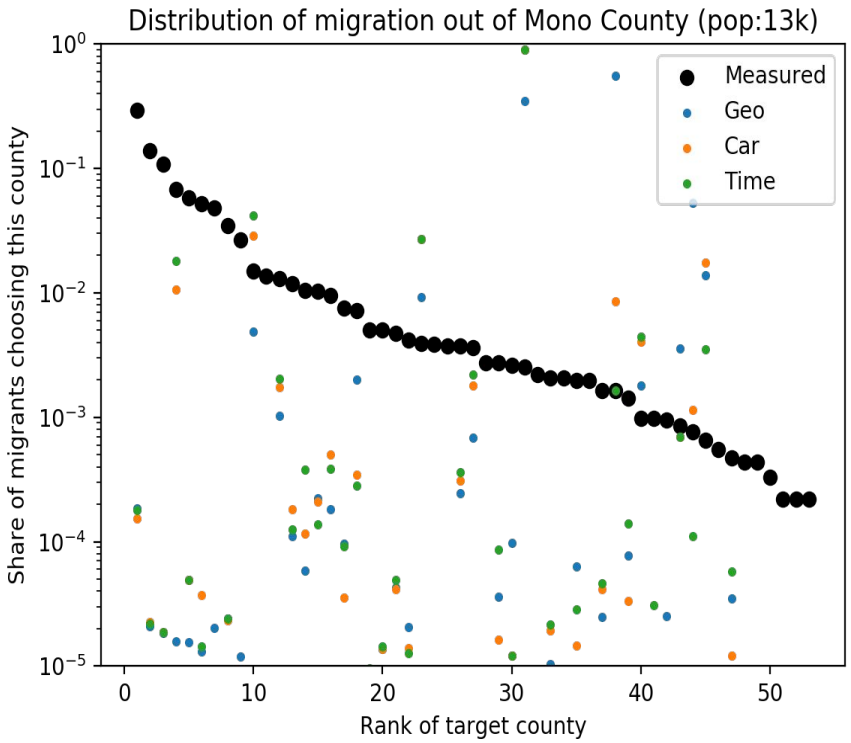
Radiation model: good fit for big counties





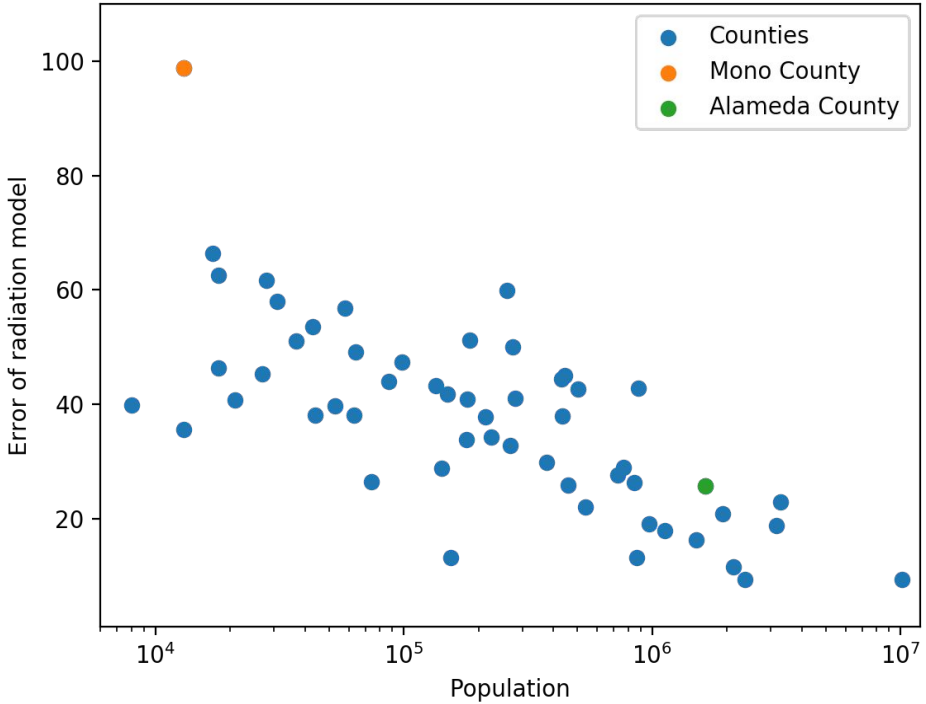
Radiation model: really bad for small counties





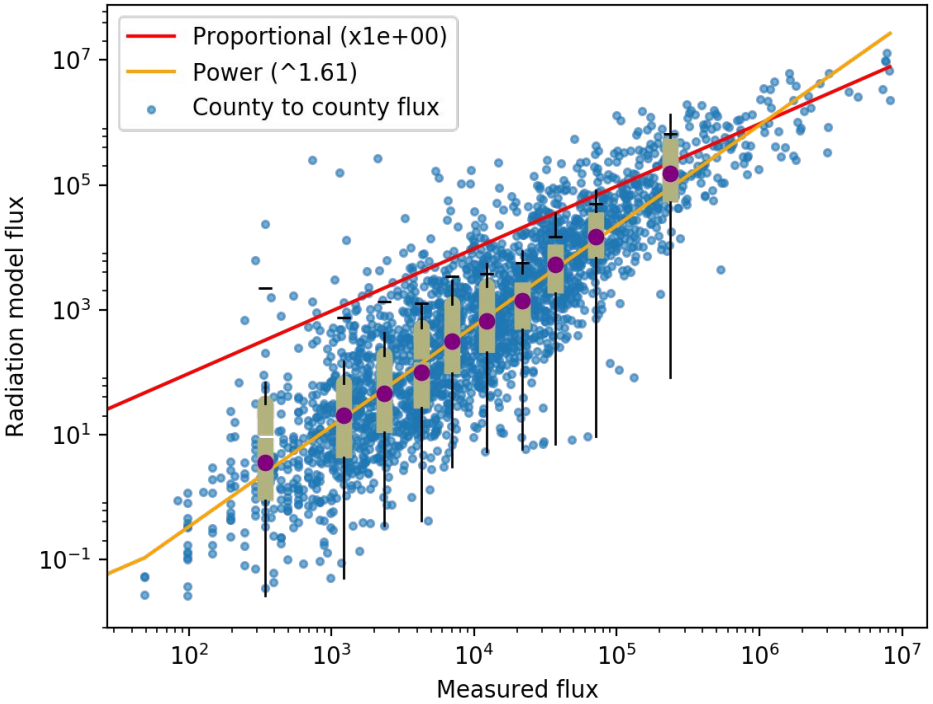
Radiation model and population

Error in model wrt county population



Radiation model: results

Prediction of model vs Measure

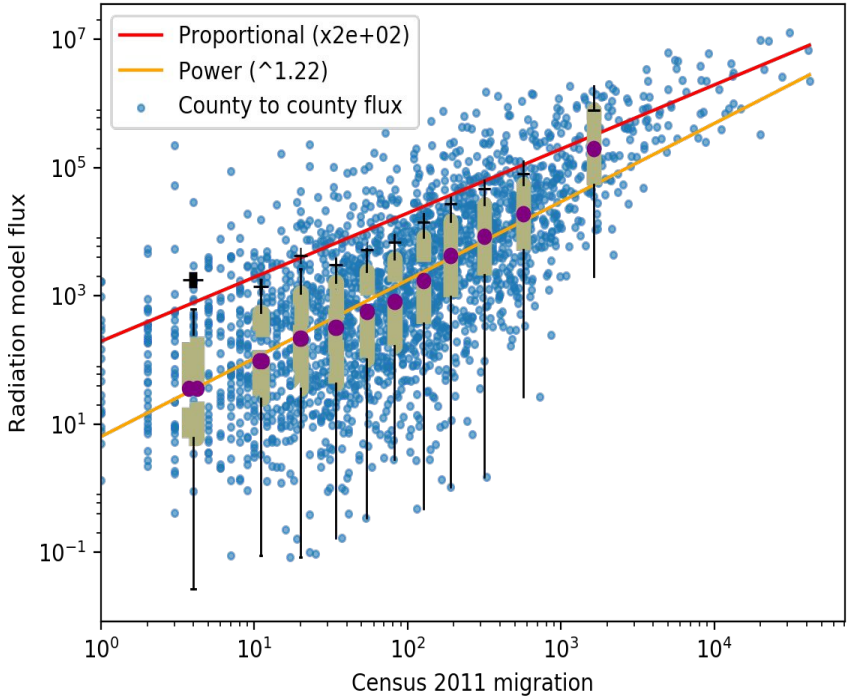


Two different modes?

Big counties must have more general (tertiary) infrastructure
Small counties must have mostly non-specialized (primary) hospitals

Need for specific models
⇒ Specialization of hospitals?

Supplementary material : radiation vs Census

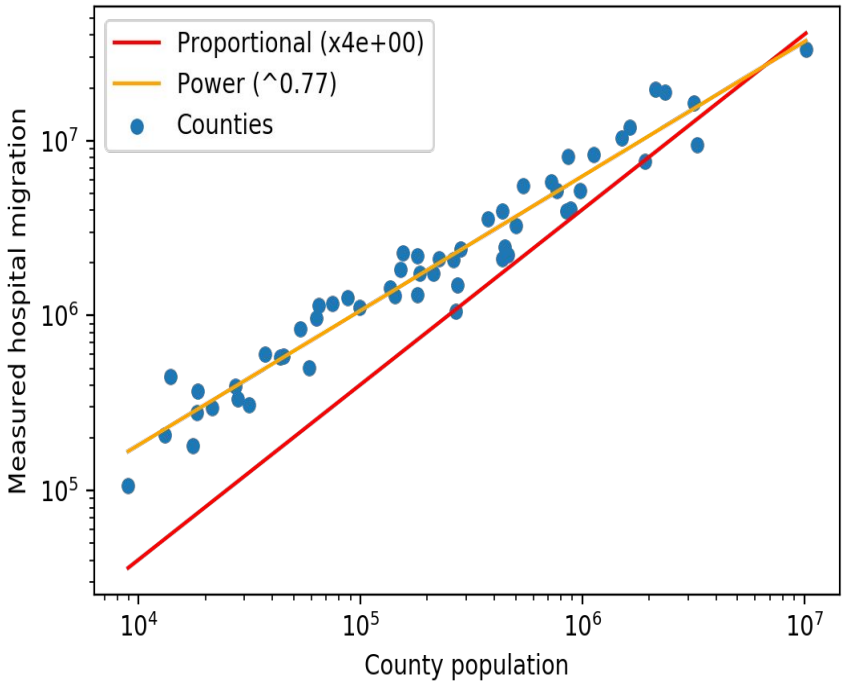


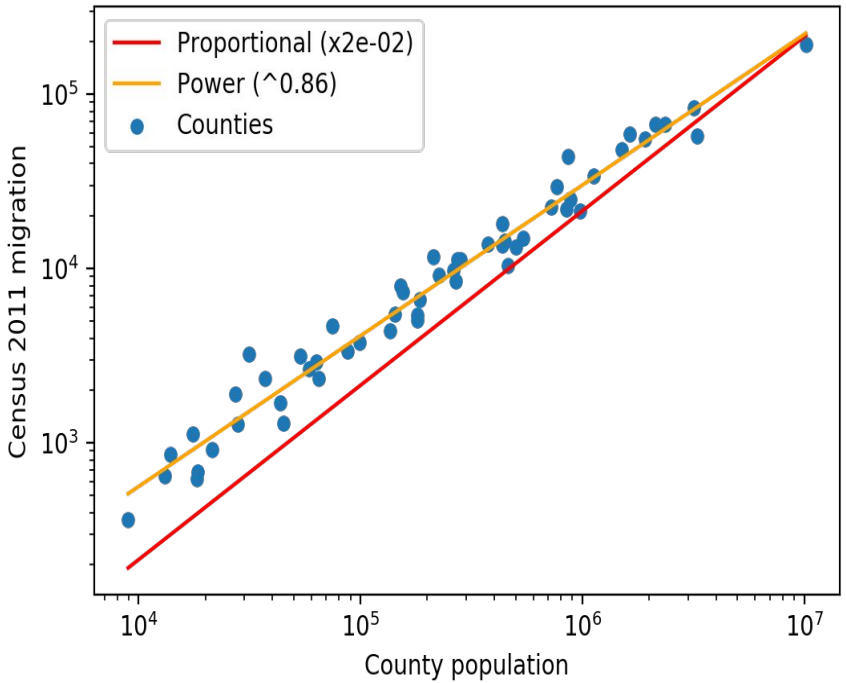
Not exactly linear
but better than health mobility
Two modes again?

Possible sources of error:

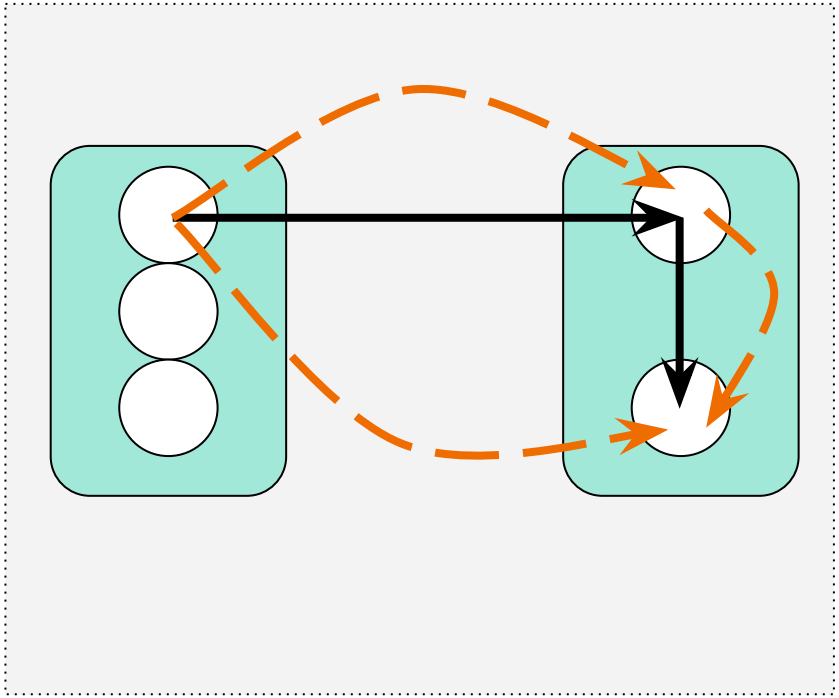
- directed graph specification
- county aggregation
- distance computation

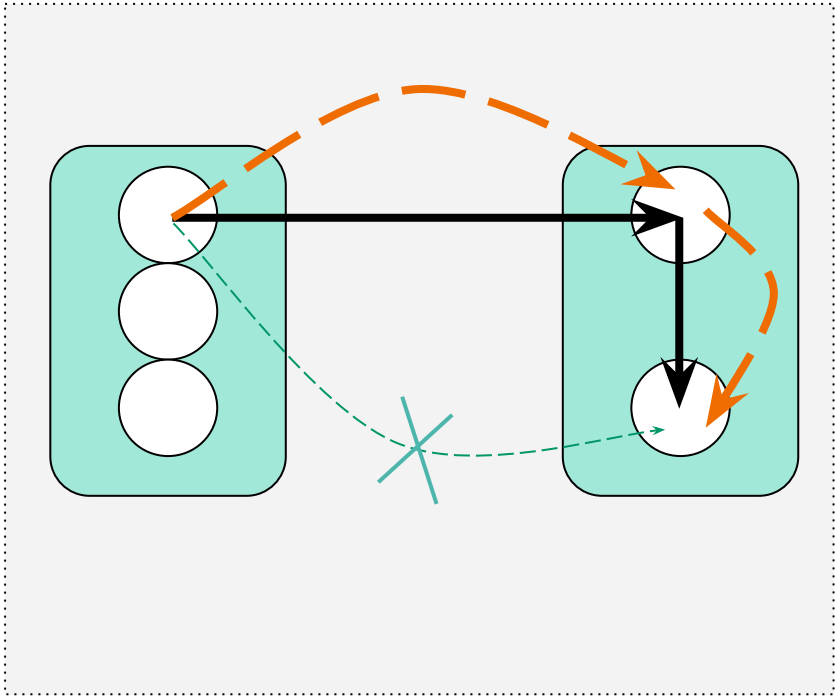
Supplementary material : migration vs population



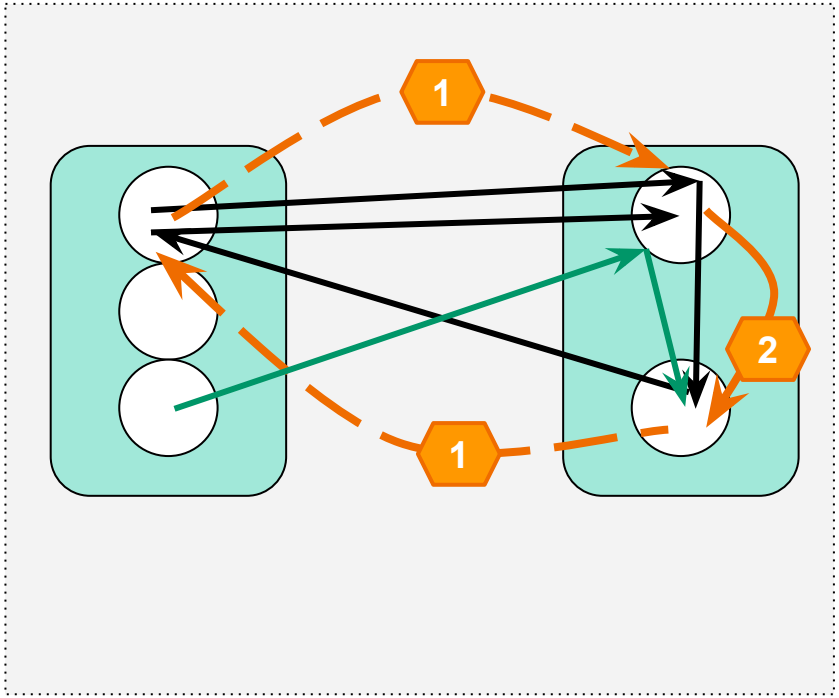


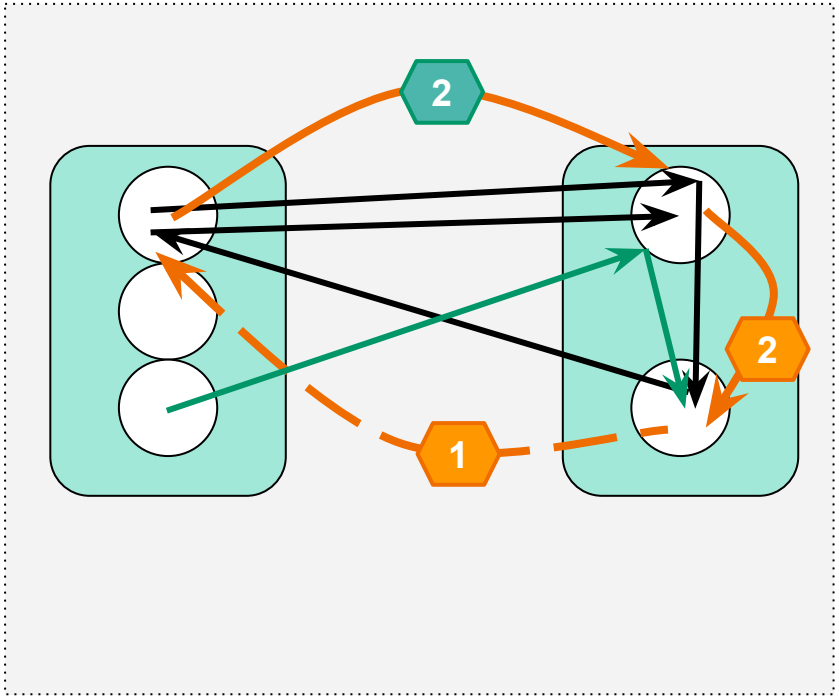
Network re-definition: transitivity



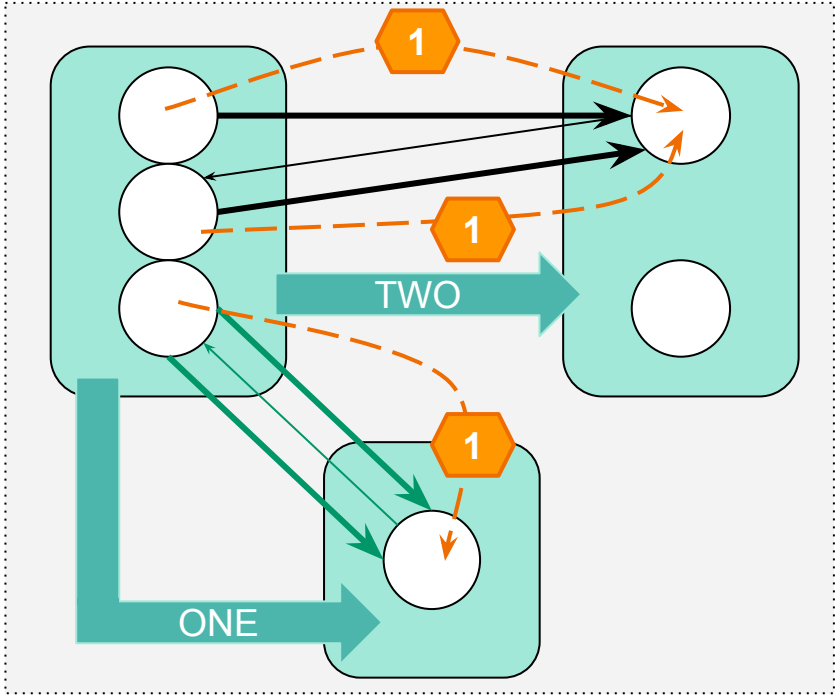


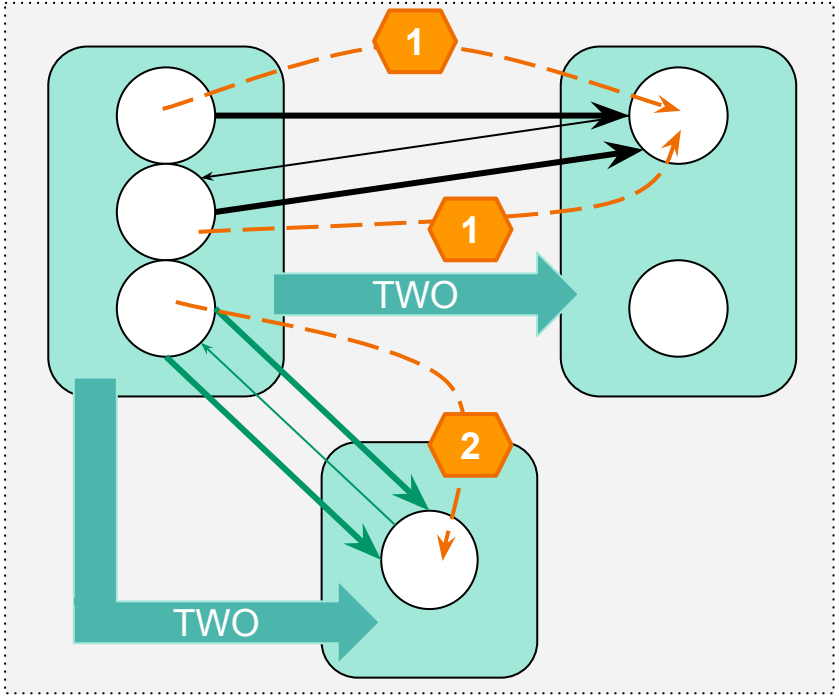
Network re-definition: multiple edges



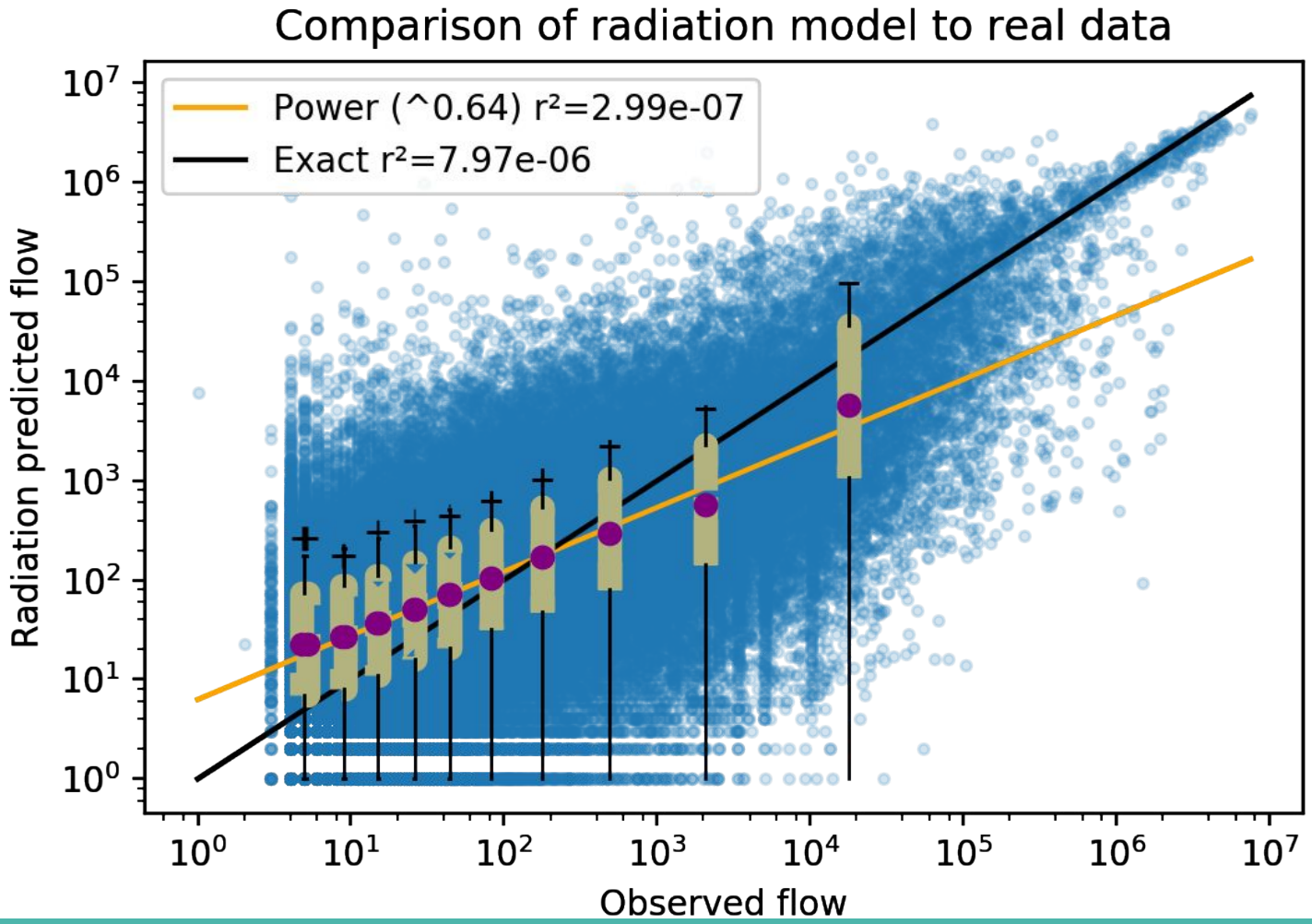


Network re-definition: aggregation

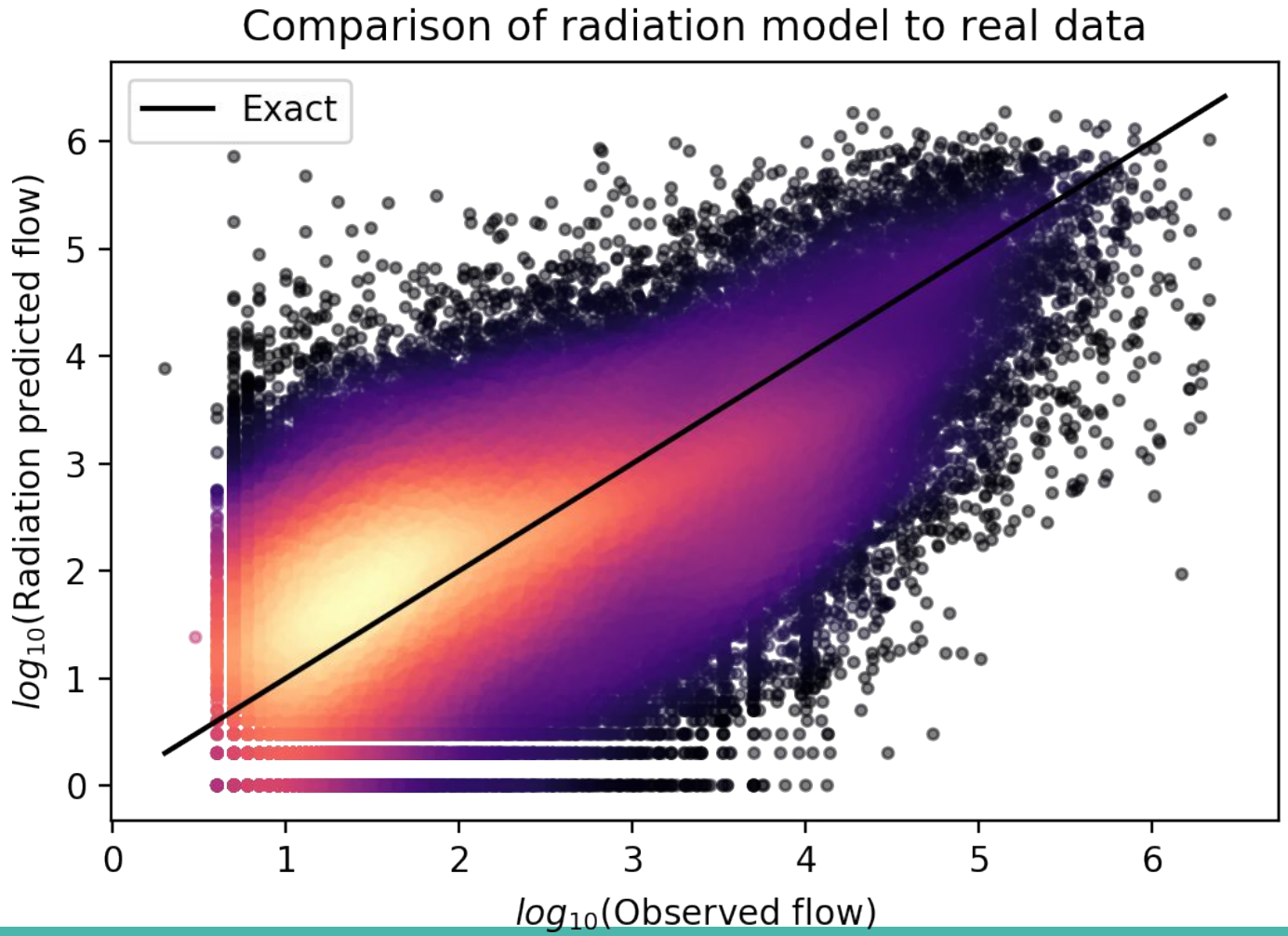




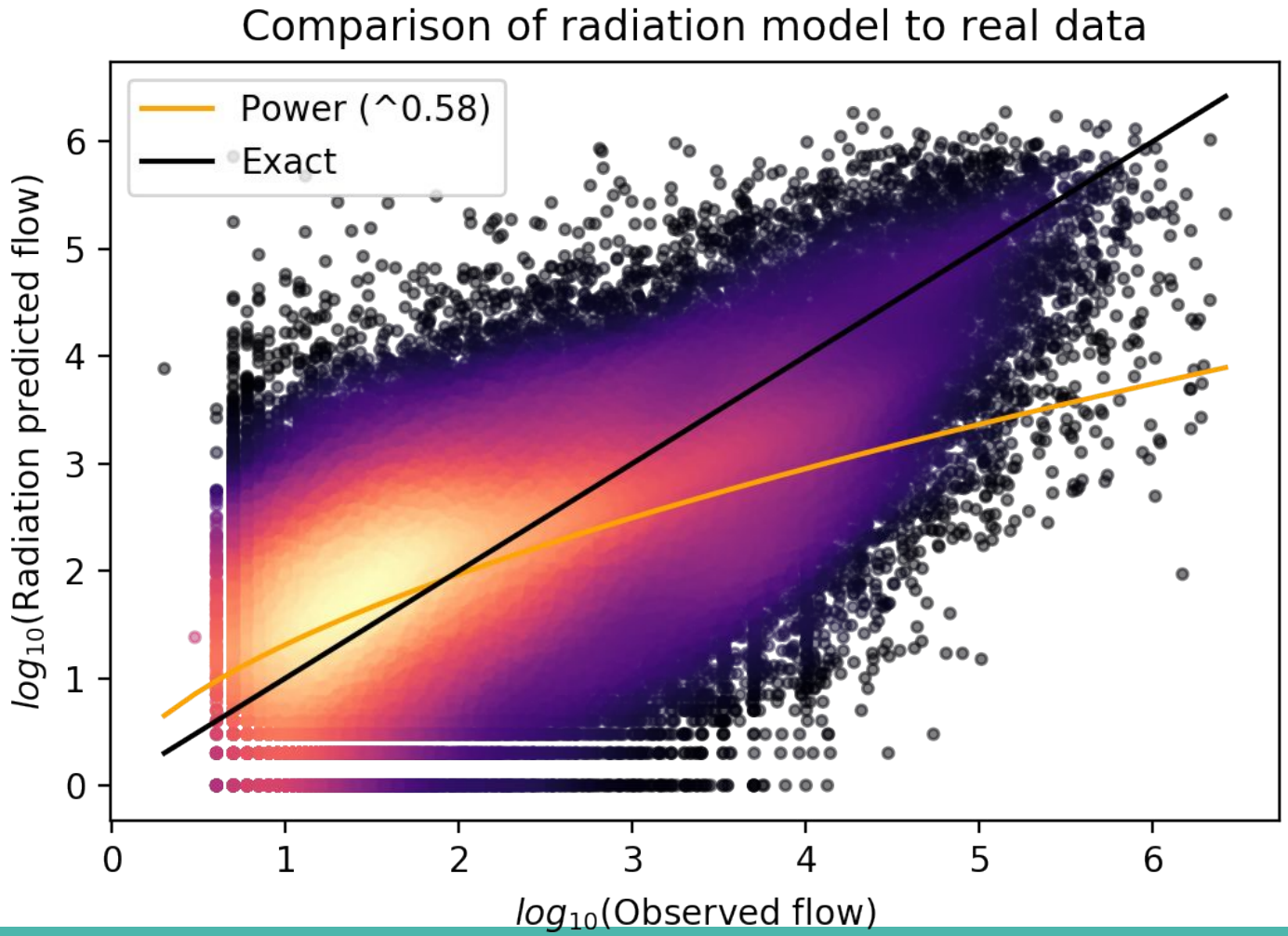
Results


Comparison of radiation model to real data
Power (^0.64) r²=2.99e-07
Exact r²=7.97e-06
Radiation predicted flow
Observed flow
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7

Results


Comparison of radiation model to real data
Exact
log_{10}(Radiation predicted flow)
log_{10}(Observed flow)
0
1
2
3
4
5
6

Results


Comparison of radiation model to real data
Power (^0.58)
Exact
log_{10}(Radiation predicted flow)
log_{10}(Observed flow)
0
1
2
3
4
5
6

Gravity & Radiation

$$G\frac{m_i m_j}{r^{\alpha}}$$

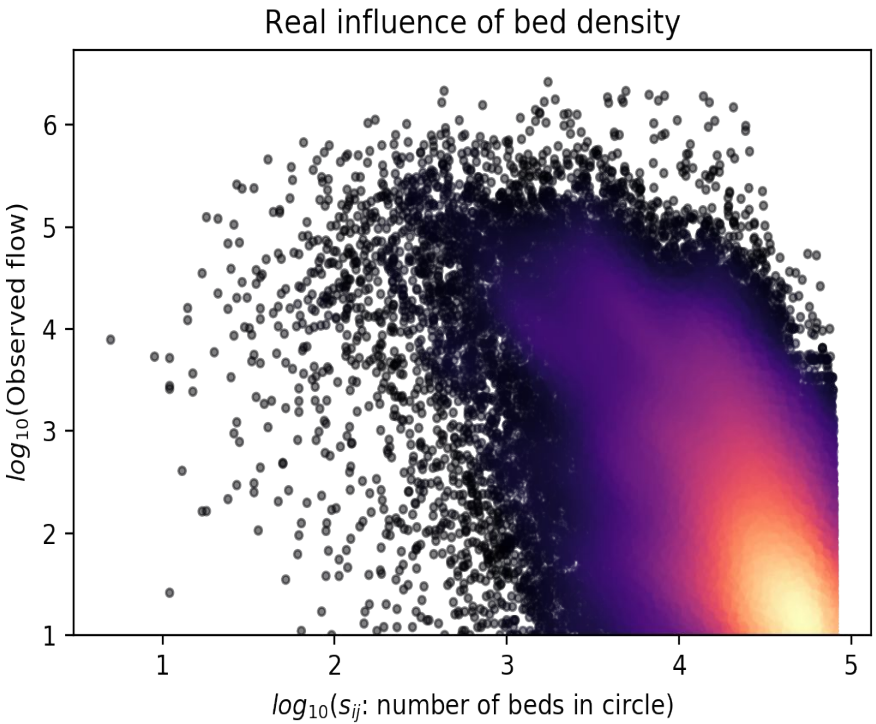
Geographic distance

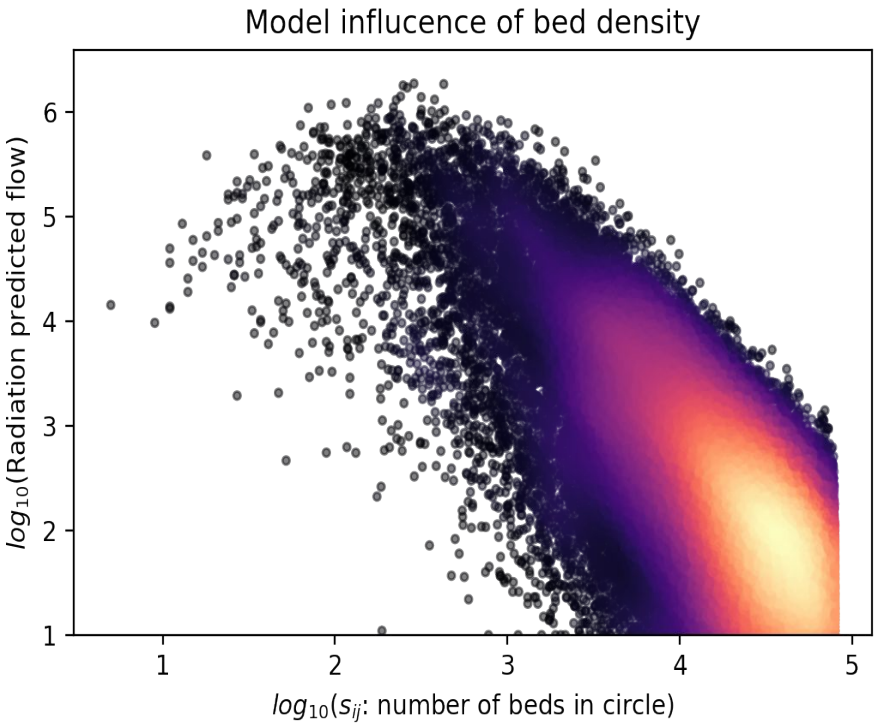
Number of beds

Number of beds in circle

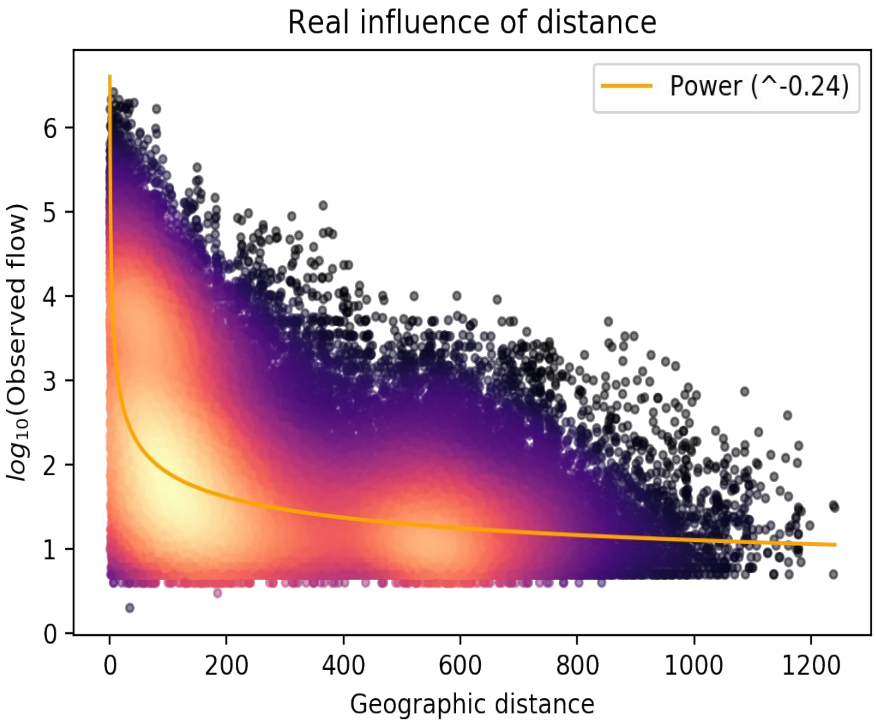
$$T_i \frac{m_i m_j}{(m_i + s_{ij})(m_i + m_j + s_{ij})}$$

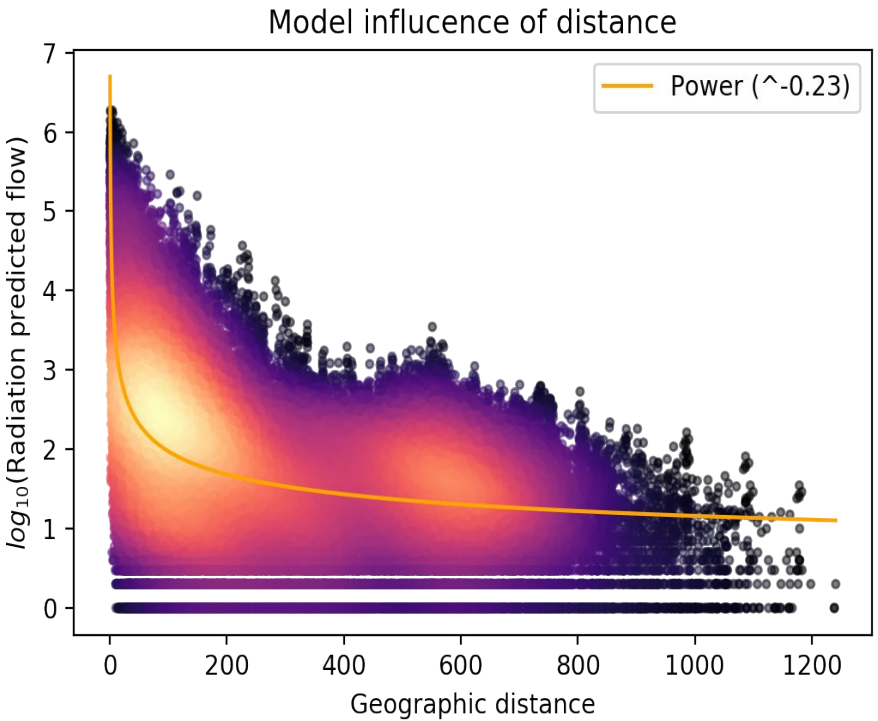
Beds in circle s_{ij}



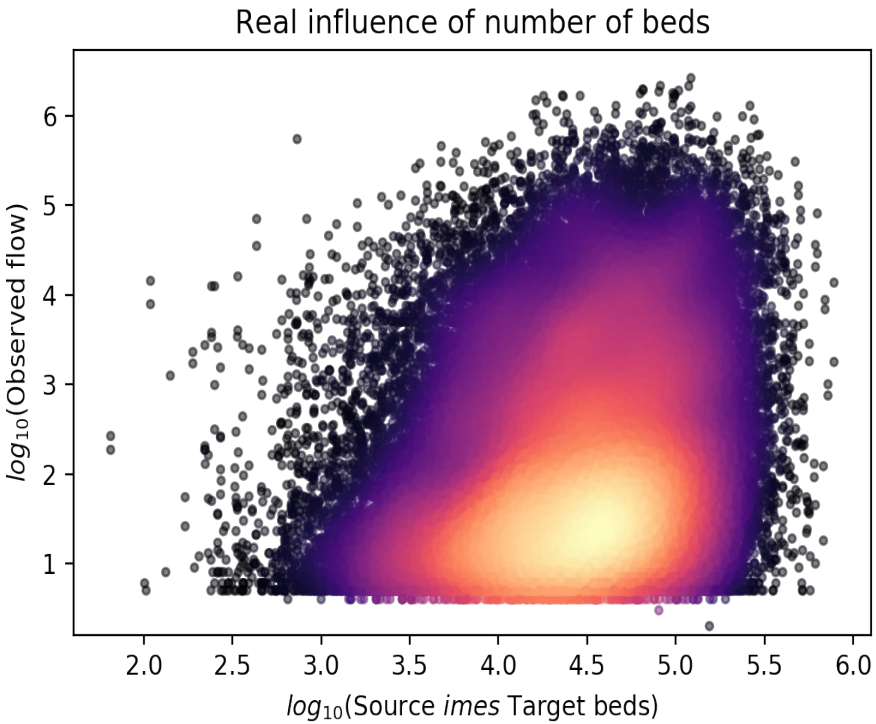


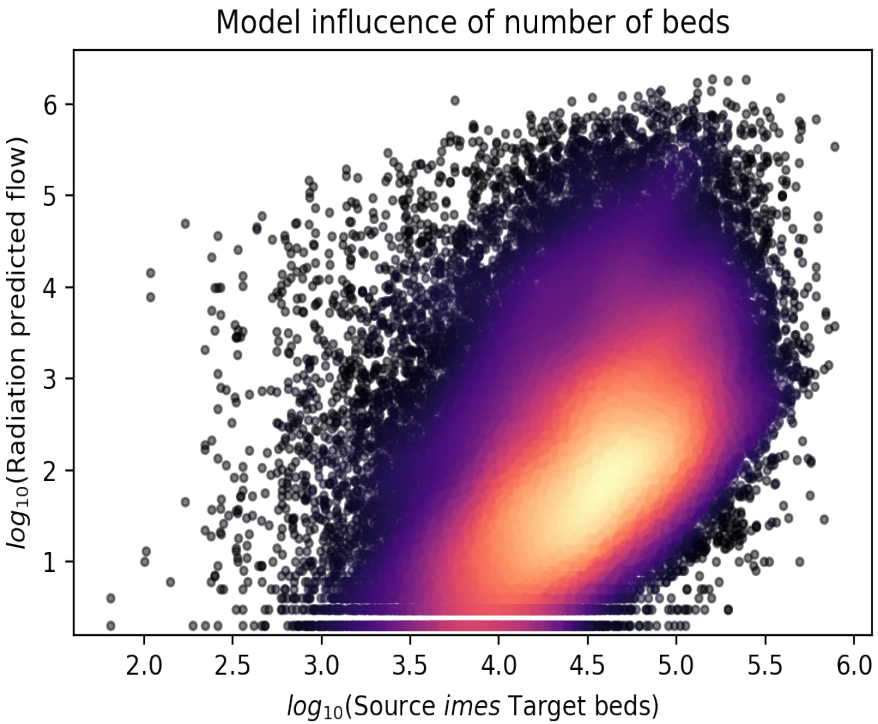
Distance r


Real influence of distance
Power (^-0.24)
log_{10}(Observed flow)
Geographic distance
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200


Model influcence of distance
Power (^-0.23)
log_{10}(Radiation predicted flow)
Geographic distance
0
1
2
3
4
5
6
7
0
200
400
600
800
1000
1200

Number of beds $m_i \times m_j$





Define a new 'mass' for hospitals $\tilde{m}_i$

Vertex-related

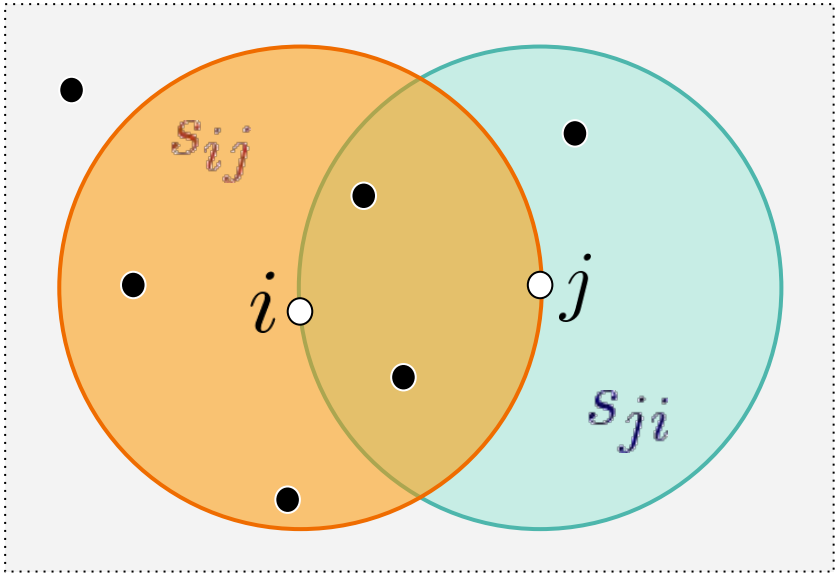
Size (number of beds)
Rank (Marc)
Teaching status
Rural / urban

Edge-related

Centrality (Amar)
Alliances

Patient-related

Insurance status
Rehabilitation
Specialty


s_{ij}
i
j
s_{ji}