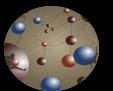


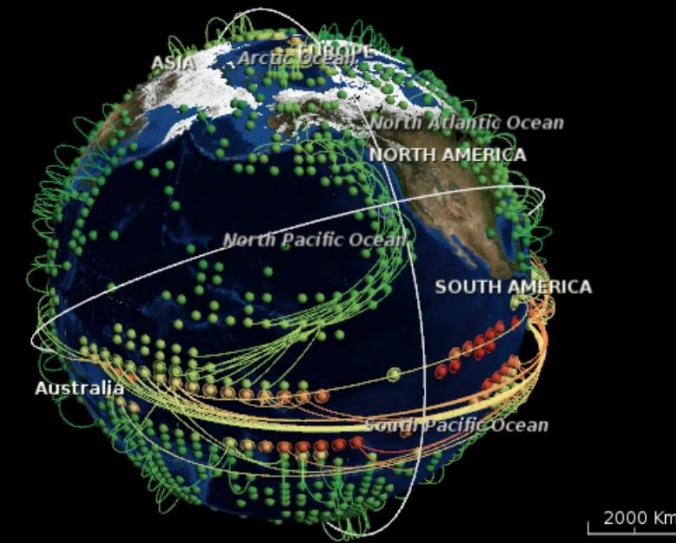
# Network analysis: How can we benefit from our travels?



Liubov Tupikina (CRI, Lecturers without borders)

2 August, CorrelAid, Berlin, Germany





About me:  
networks, spreading,  
diffusion, data analysis of  
mobility transportation  
systems  
@lyuibov

Phd in theoretical physics (PIK,  
HU Germany)  
Applied maths, data analysis,  
biophysics projects (HU, UU,  
Ecole X, Tokyo Tech, CRI, MIPT)

Lecturers without borders  
(co-founder),  
Open network of  
researchers from around  
the globe

# LECTURERS WITHOUT BORDERS

Who we are?

Scientists, educators  
traveling around the  
globe

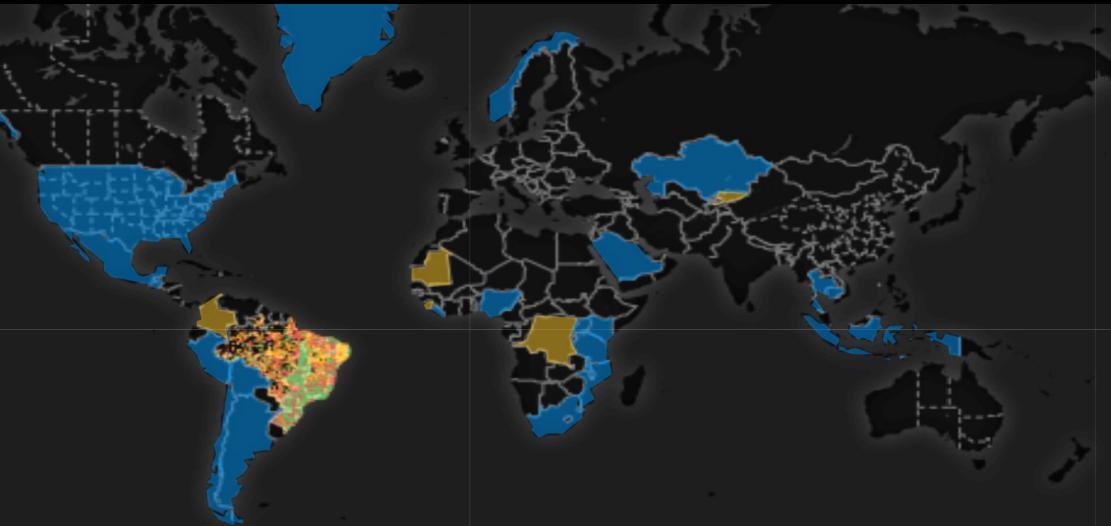
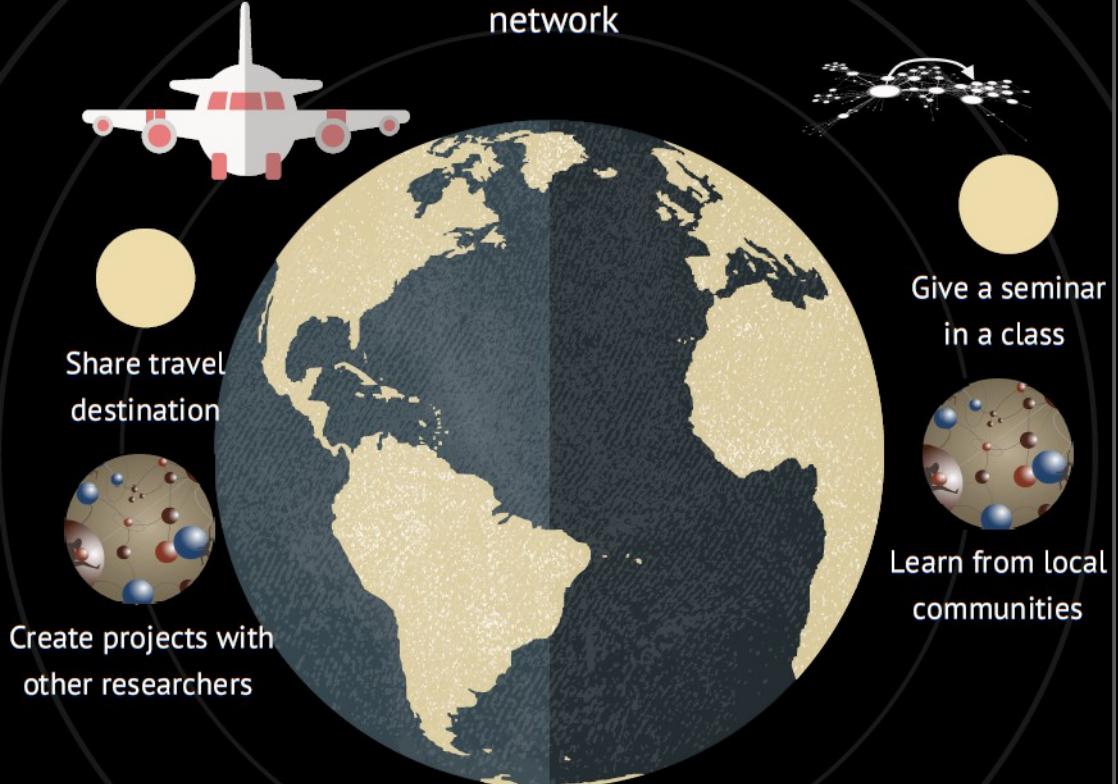


# 12

countries in our  
network

OUR GOAL

Link schools and  
traveling scientists  
[www.scied.network](http://www.scied.network)



# Lecturers without borders project: How this works?



## Algorithm:

1. Scientists share their google location,
2. Coordinator connects them with local educational initiatives,
3. Scientists are making lectures in local schools.



# Lecturers without borders project: How this really works?



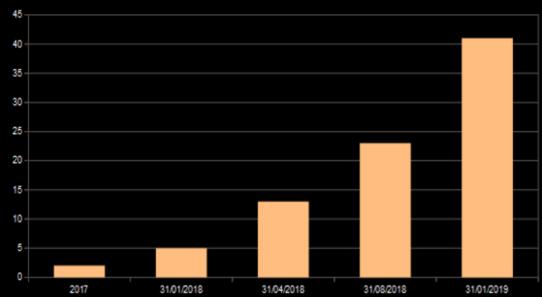
## Information collection:

1. Matching scientists and schools,
2. Analysis of researchers mobility,
3. Open network of educational associations around the globe.



# “Lecturers without borders”: proof of the concept

# Numbers of schools since 2017

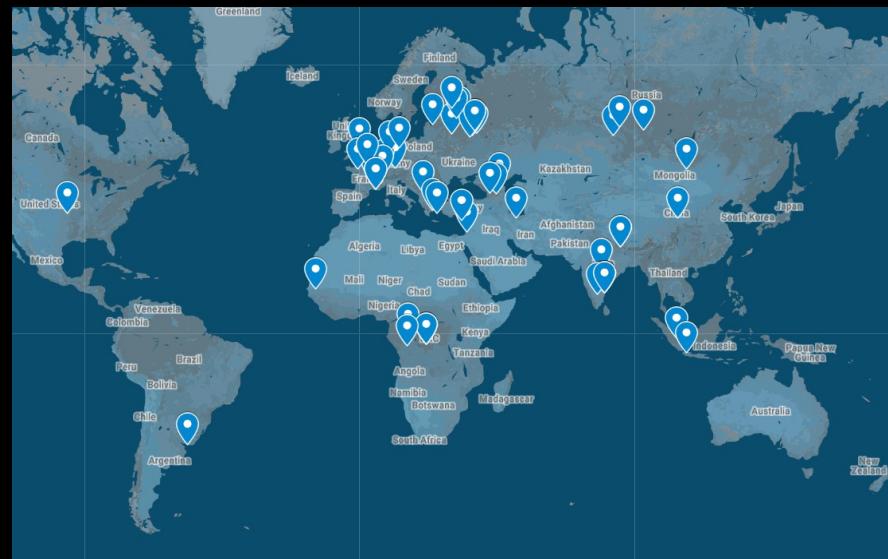
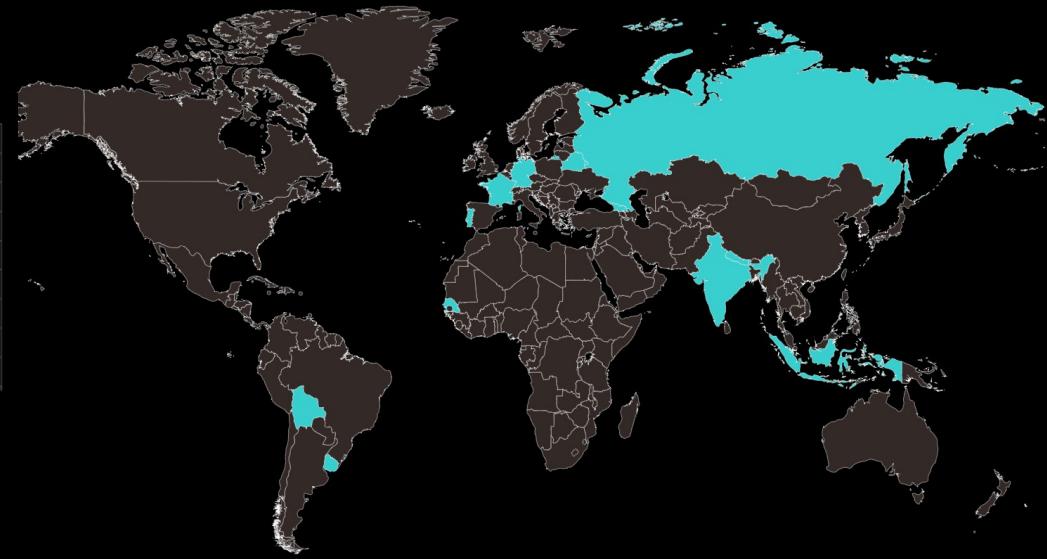


Number of active scientists/coordinators: 39

Number of lectures/seminars: 3 (2017) – 29 (2019)

Number of established connections: 91 in 12 countries

## How to get information about travels: global and individual?





## Challenges: Lecturers without borders project

- Highly sensitive location data:  
How to identify locations where help is needed?  
Can any person share geo-location?  
"If you share it, you are ready to connect..."
- Missing data:  
A lot of data is missing, how to optimize the whole process?
- Sensitive data can't be shared by associations:  
Do educational and medical associations collaborate?

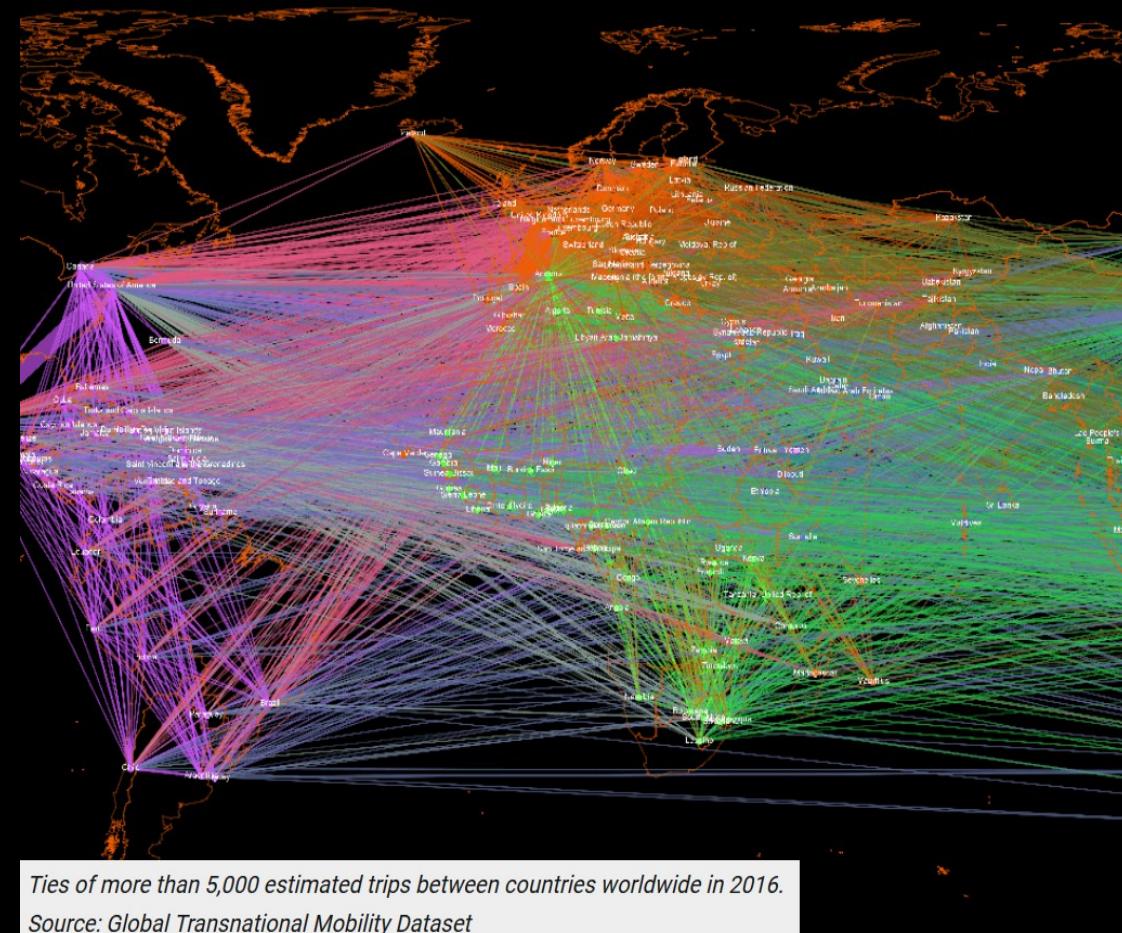
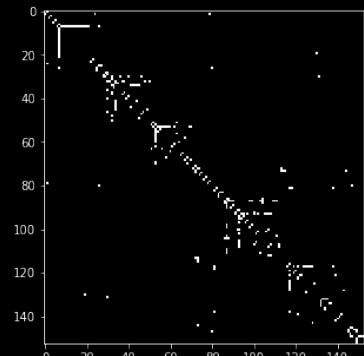
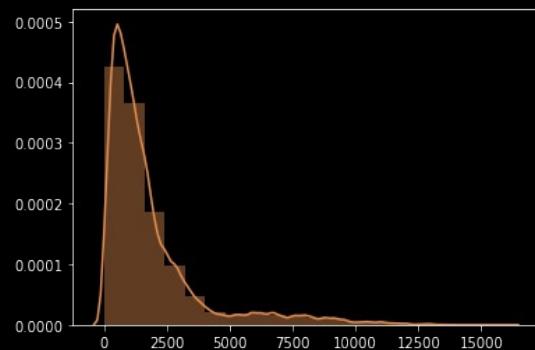


[1] Proc. Multilayer network (2017)  
[www.scied.network](http://www.scied.network) <https://osf.io/7v9xt/>

[2] OpenHumans.org  
[3] Git Unicef magic box

# Global travel patterns: How people are traveling?

Openflights network and subnetworks:  
Erasmus travel networks, Marie-Curie EU network

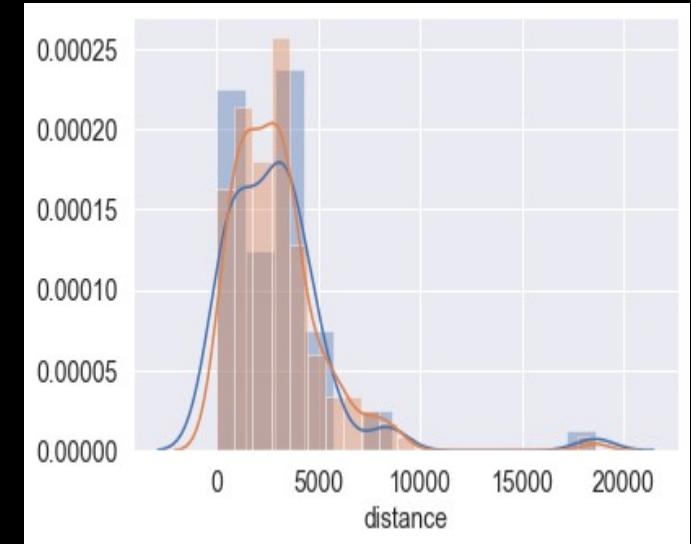


- [1] The scaling laws of human travel, Brockmann, Nature 2006
- [2] [github/Liyubov](https://github.com/Liyubov) <https://github.com/Liyubov>
- [3] Openflights data, Erasmus data

## How individuals are traveling?

Most of the time we travel on short distances:

- analysis of banknotes
- analysis of phone data
- personal geolocation history

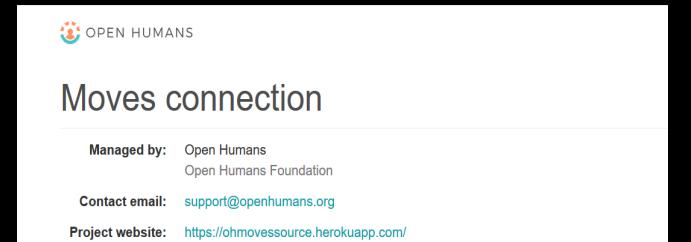
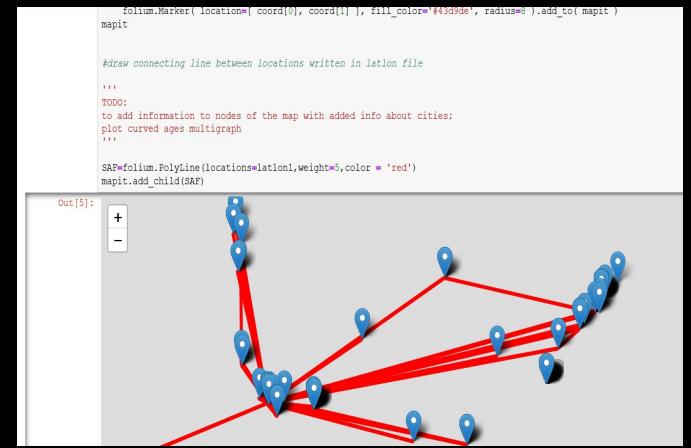


What about metadata of each individual trajectory?

[1] [www.OpenHumans.org](http://www.OpenHumans.org)

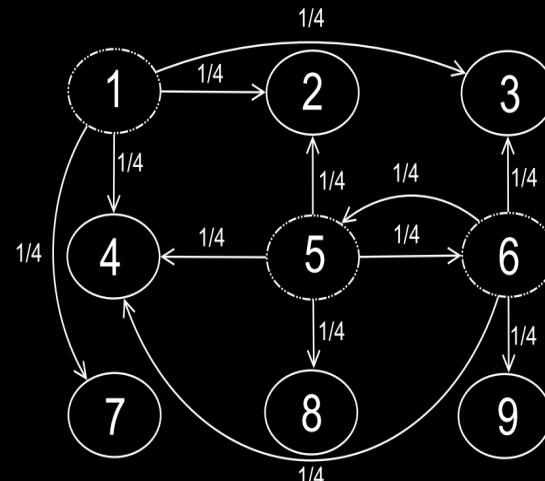
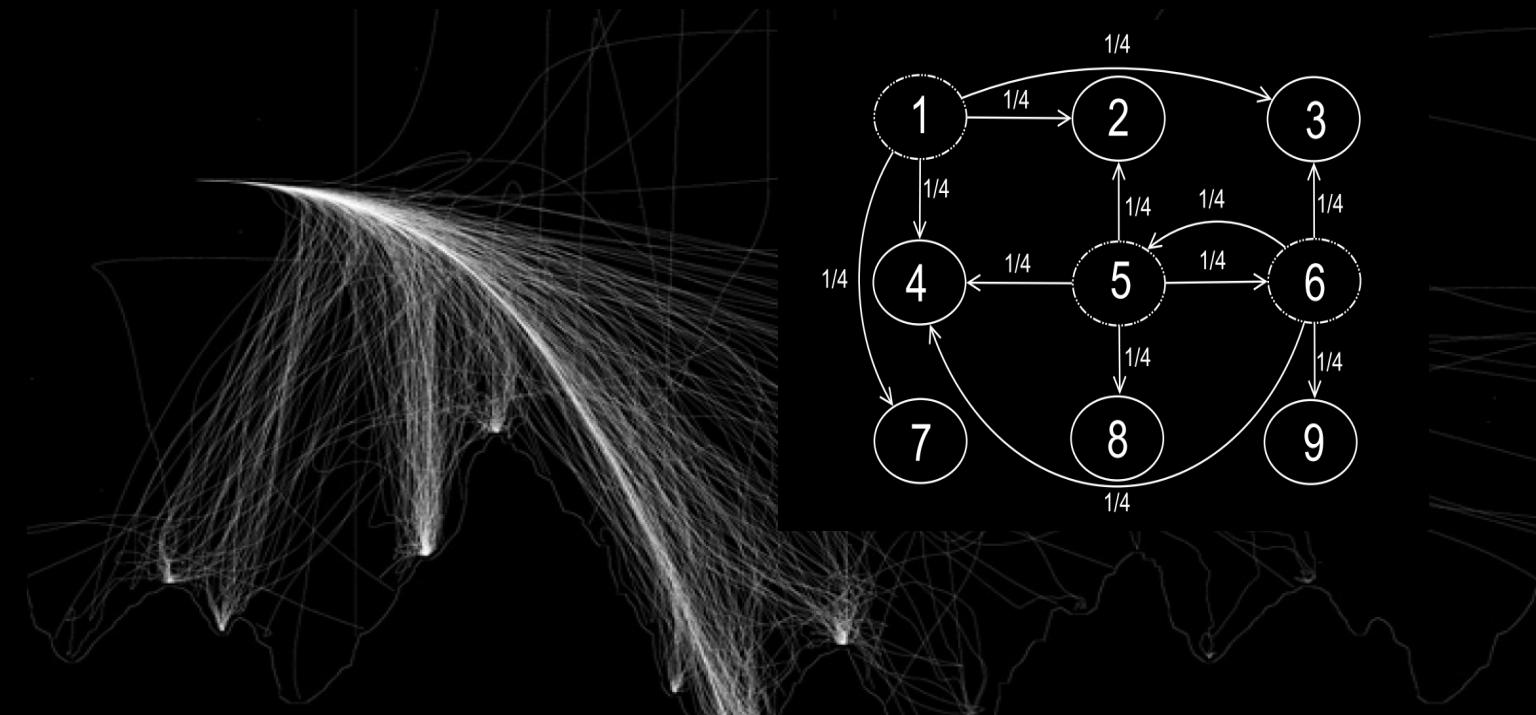
[2] <https://github.com/Liyubov>

[3] “The scaling laws of human travels”, Brockmann et al., Nature 2006



# Mathematical formalisation of the problem

Given  $m$  random walkers (**travelers**) on a network with  $N$  nodes (**cities**)  
 What is expectation time  $\langle T \rangle$  when  $n$  nodes are visited?



The predicted evolutionary speed of a star with the luminosity of P Cygni in the H-shell burning phase near  $T_{\text{eff}} = 20,000$  K is  $d \log(T_{\text{eff}})/dt = -0.013$  per century<sup>3</sup>, which implies a decrease in  $T_{\text{eff}}$  of only 3% per century. This is about half the observed value of 6% per century. So the observed evolution speed of P Cyg is twice as fast as predicted. The discrepancy between the observed and predicted evolutionary speed might be due to two effects: (1) The calculated evolutionary speed might be wrong because the outer layers of the star expand faster than predicted. In fact, recent calculations of the evolution of luminous stars by A. Maeder (personal communication) suggest that dynamical effects due to radiation pressure in the envelope of the star result in a more rapid expansion of the star and consequently also in a more rapid decrease in  $T_{\text{eff}}$  than predicted

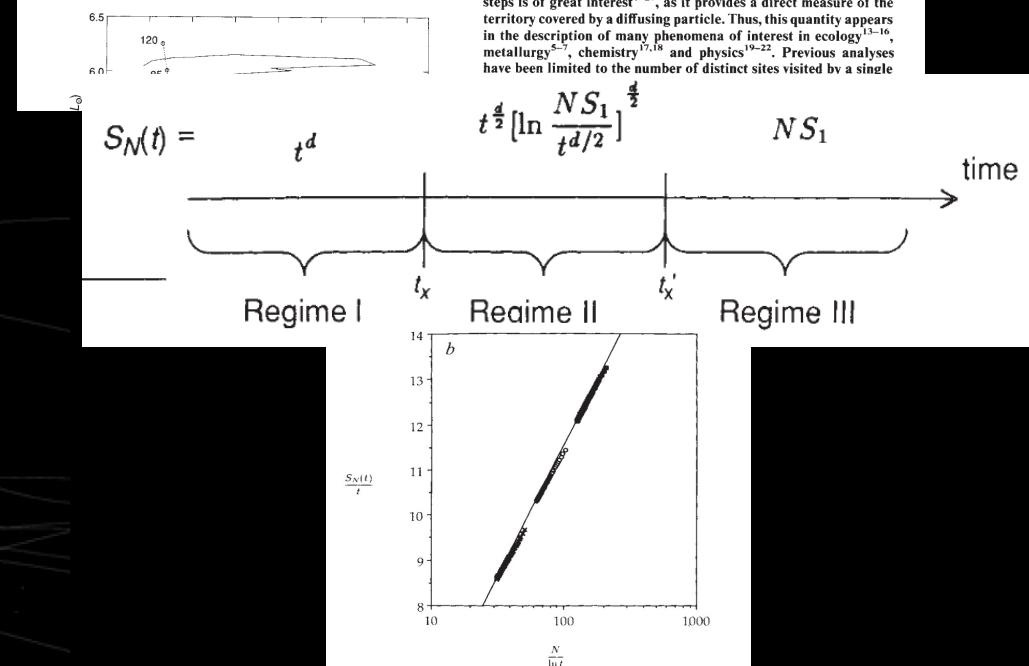
## Territory covered by $N$ diffusing particles

Hernan Larralde\*, Paul Trunfio\*, Shlomo Havlin\*†,  
 H. Eugene Stanley\* & George H. Weiss†

\* Center for Polymer Studies and Department of Physics,  
 Boston University, Boston, Massachusetts 02215, USA

† Physical Sciences Laboratory, Division of Computer Research and  
 Technology, National Institutes of Health, Bethesda, Maryland 20892, USA

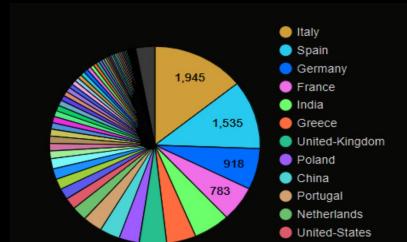
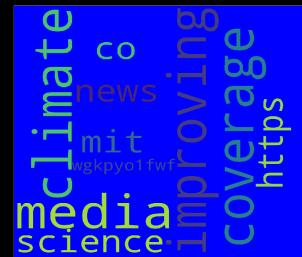
THE number of distinct sites visited by a random walker after  $t$  steps is of great interest<sup>1–21</sup>, as it provides a direct measure of the territory covered by a diffusing particle. Thus, this quantity appears in the description of many phenomena of interest in ecology<sup>13–16</sup>, metallurgy<sup>2–7</sup>, chemistry<sup>17,18</sup> and physics<sup>19–22</sup>. Previous analyses have been limited to the number of distinct sites visited by a single



- [1] Erdos, Dvoretzky Proc.Berkley (1951)
- [2] Tupikina et al. Appl.Netw.Journ (2018)
- [3] Larralde et al. Nature (1992)

# Other open problems

1. How to facilitate exchange of information between educational institutions in OPEN network? What is impact from possible matches between schools and traveling experts?
2. How to help **coordination** for Lecturers without borders in remote areas with minimal internet connection?
3. What is the best **framework for retrieving information about researchers' mobility, meta-data** from social networks, conferences databases?



Collaborations



This map visualizes which other institutions researchers from **Bharath University** have collaborated with.

[1] [www.scied.network](http://www.scied.network)

[2] [github/lecturers-without-borders](https://github.com/lecturers-without-borders)

# Collaborate

If you are interested to participate in Lecturers without borders as coordinator or as manager, write to us [liubov.tupikina@cri-paris.fr](mailto:liubov.tupikina@cri-paris.fr) (together with Munich, Germany, CRI, France)

Give a seminar- lecture in local school register at  
[www.scied.network](http://www.scied.network)

Collaborate on data analysis  
<https://github.com/lecturers-without-borders>  
Happy to collaborate with CorrelAid...

Other ideas?

@lyuibov  
[liubov.tupikina@cri-paris.org](mailto:liubov.tupikina@cri-paris.org)



1. NetSciEd 2017 proceedings, multilayer network approach
2. OpenHumans project
3. Lectures without borders [www.scied.network](http://www.scied.network)
4. citizen science module

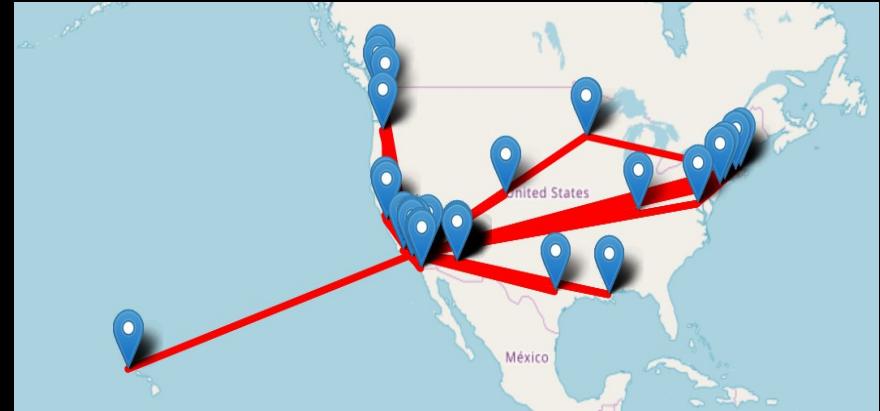




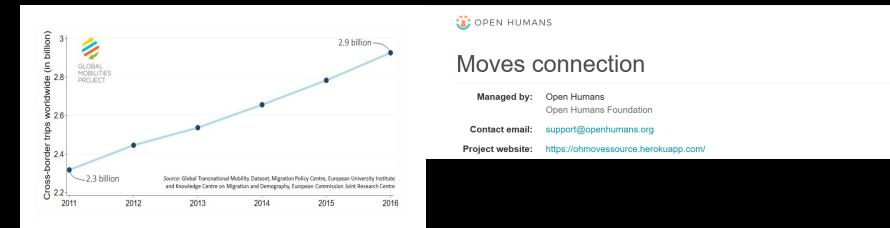
## How people are traveling: analysis of individual trajectories?

Most of the time we travel on short distances:

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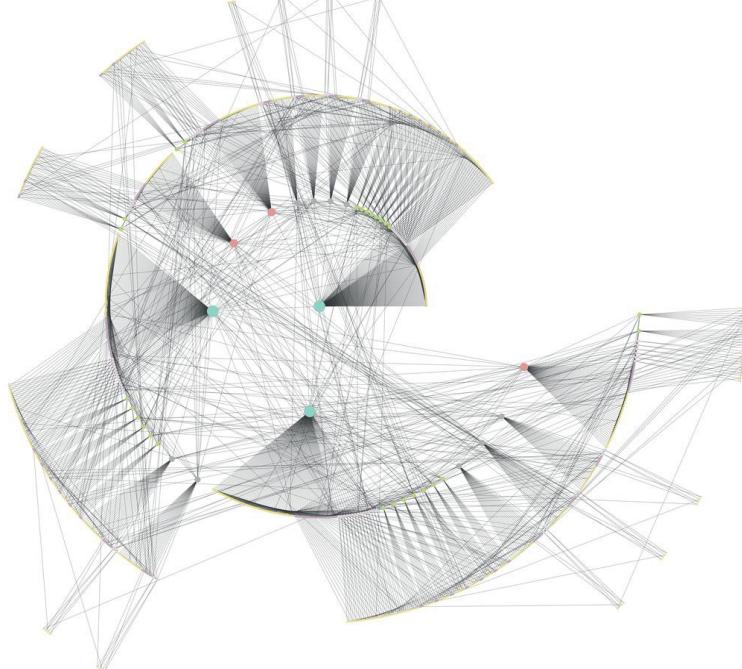


What about metadata?



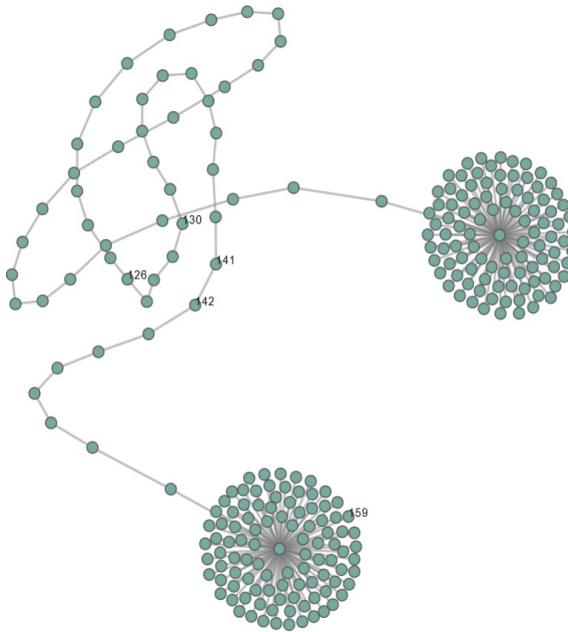
# What I am really working on...

Random networks



Modelling spatially embedded networks

Data analysis for social good:

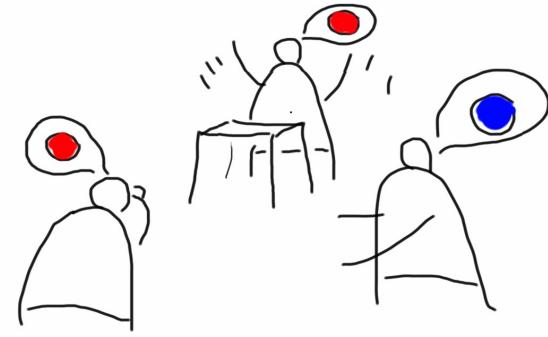


D.Grenbenkov, LT. PRE (2017)  
P. Holme, LT, New Jour. Physics (2018)  
indner, N.Molkenthin, LT, R.Donner Springer (2019)

# What I am also working on...

Spreading dynamics:

$$P_{x_0 x_a}(t) = \sum_{n=1}^{\infty} (Q^n)_{x_0 x_{abs}} P_n(t) = \frac{e^{-t/\tau}}{\tau} \sum_{n=1}^{\infty} (Q^n)_{x_0 x_a} \frac{(t/\tau)^{n-1}}{(n-1)!}$$



Modelling crowded dynamics:

$$\dot{P}_{x_0 \bar{x}}(t) = \frac{d}{dt} \int_0^t \left( \frac{1}{2} \sum_{x'=\bar{x}\pm 1} M_{x'}(t-t') P_{x_0 x'}(t') - M_{\bar{x}}(t-t') P_{x_0 \bar{x}}(t') \right) dt'.$$



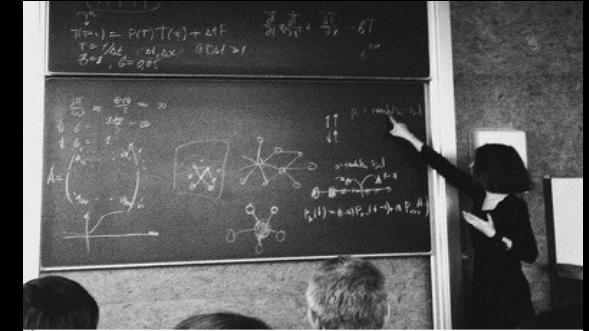
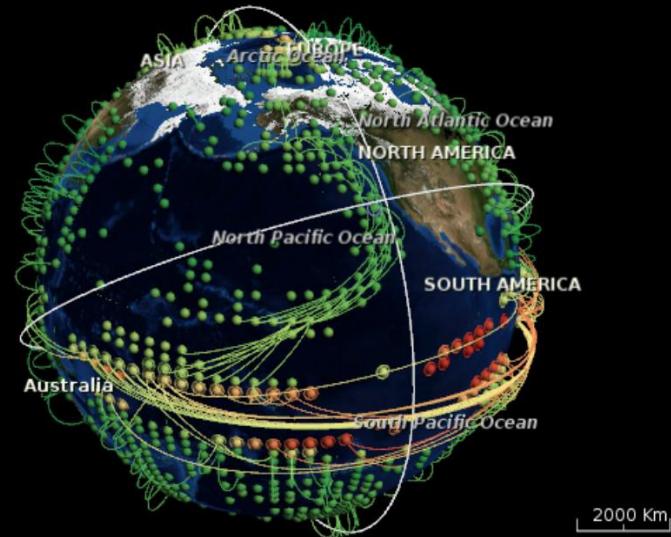
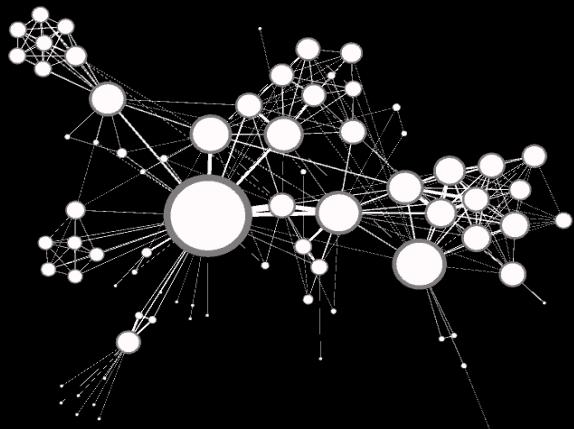
Data analysis:

If you want to  
know more ..



2.16

D.Grenbenkov, LT. PRE (2017)  
P. Holme, LT, New Jour. Physics (2018)  
M.Lindner, N.Molkenthin, LT, R.Donner Springer (2019)



networks, spreading, data analysis  
connections between people

Donges, Heitzig, LT, Kurths et al., Chaos (2015)  
LT, Molkenthin, Hernandez-Garcia, et.al, PlosOne (2016)

[https://research.cri-paris.org/ocean-health/analyzing-heterogeneous-spreading-dynamics/  
lecturers without border scied.network](https://research.cri-paris.org/ocean-health/analyzing-heterogeneous-spreading-dynamics/lecturers-without-border-scied.network)

