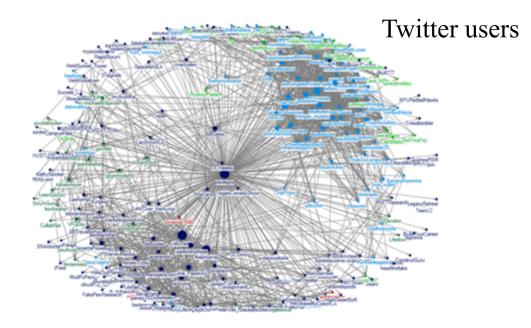
#### Mass Movements and Their Adoption in Social Media

#### Fang Jin Assistant Professor Department of Computer Science, Texas Tech University

#### Ubiquity of social media

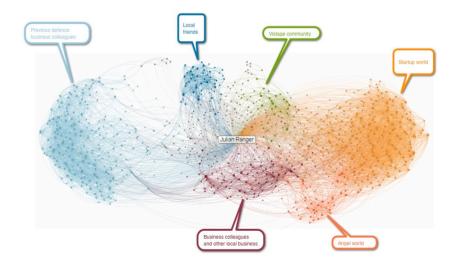
#### Facebook





#### Flickr tags

#### LinkedIn network



#### Big data research on social networks

1. How do we identify group anomaly?



2. How do we detect civil unrest events in social networks?



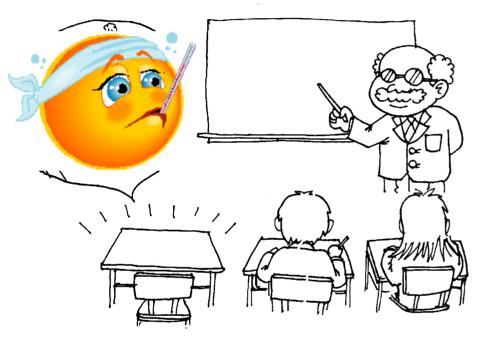
3. How do we distinguish rumors from real news?





Group Absenteeism as a basis for Event Detection

#### Motivation

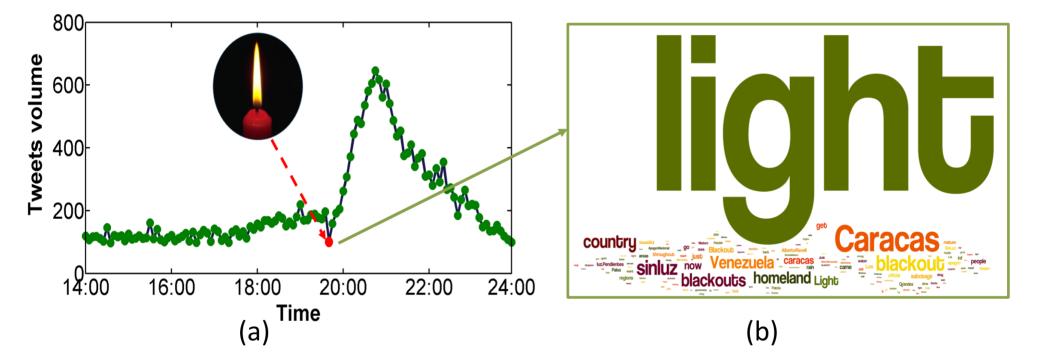




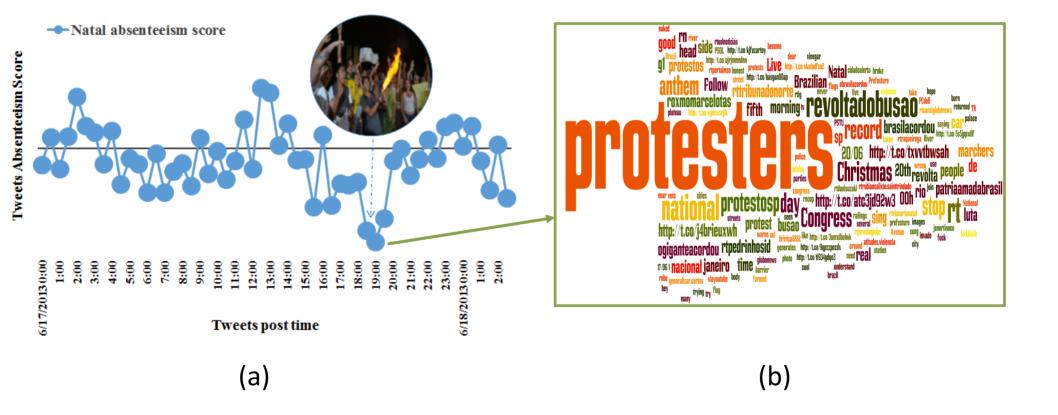


Information absenteeism

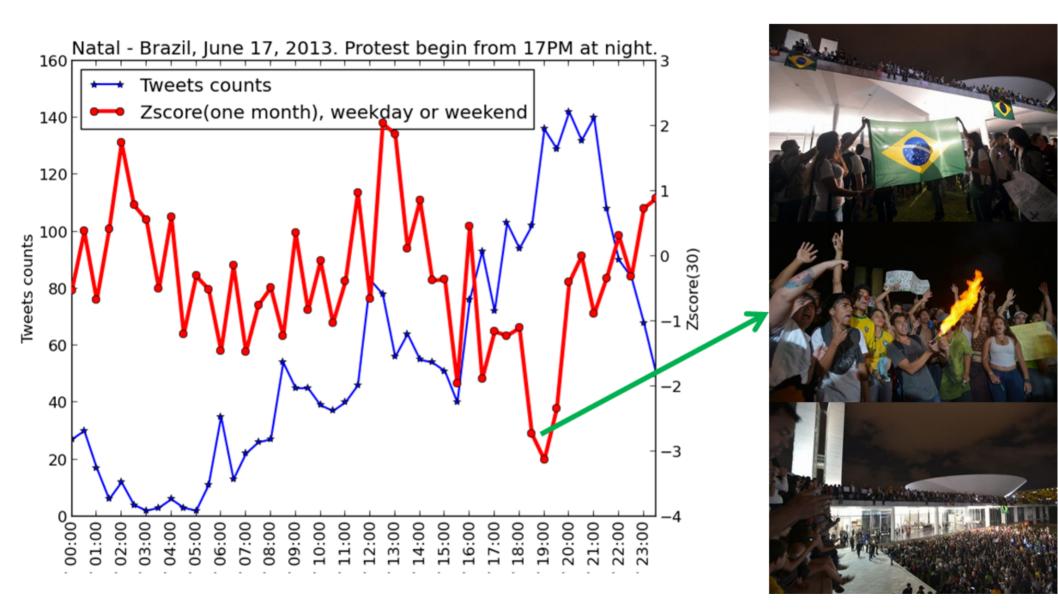
How to detect group absenteeism on Twitter?

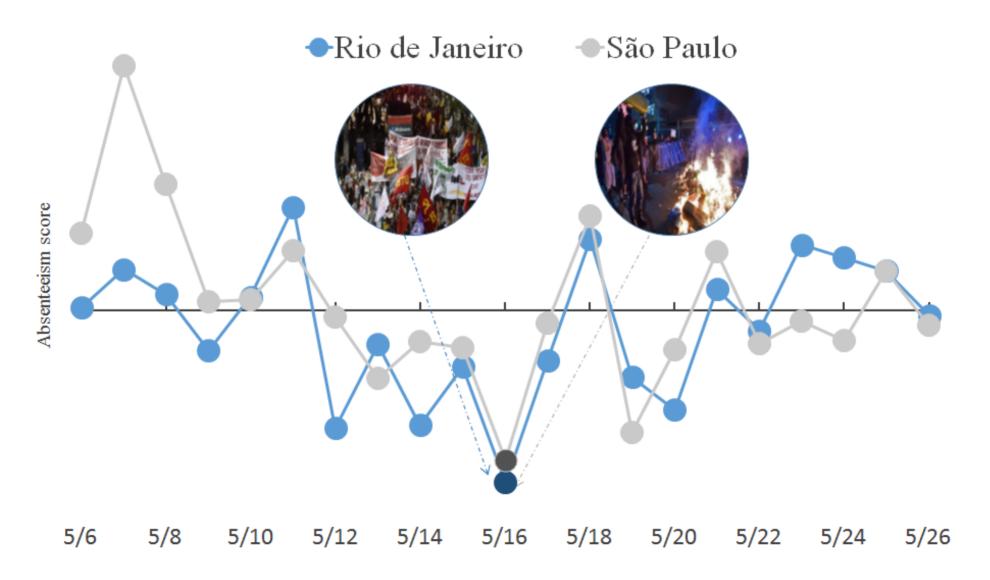


Caracas, Venezuela power cut on 2013-12-02, 8:00 PM

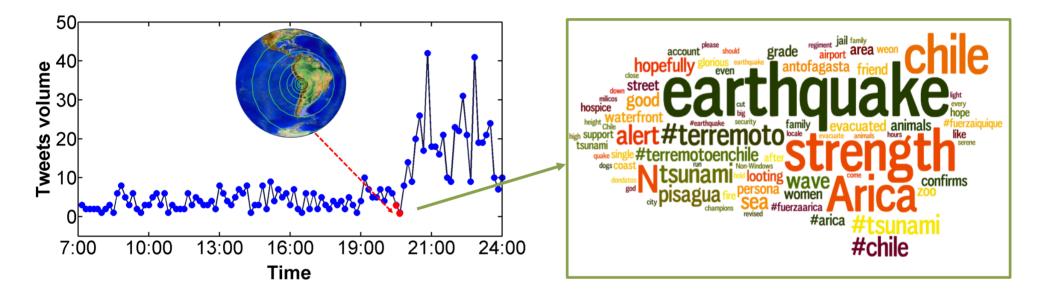


Natal, Brazil protest on 2013-06-17, 18:00 – 20:00

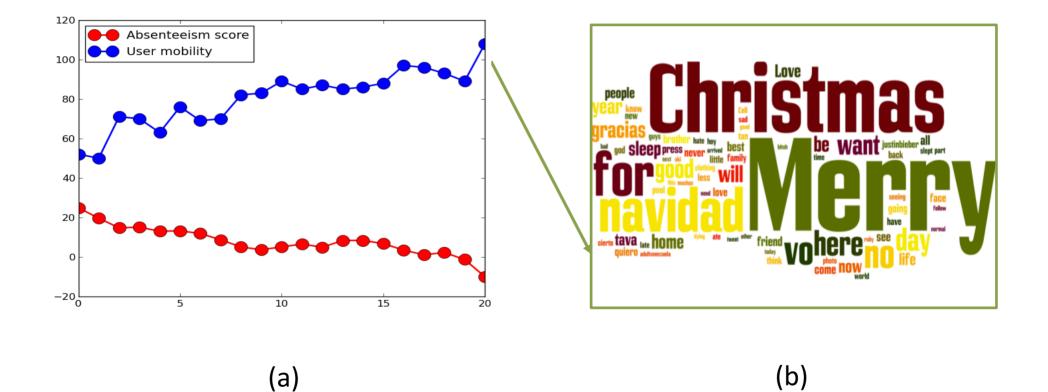




Protests in Brazil against world cup, 2014

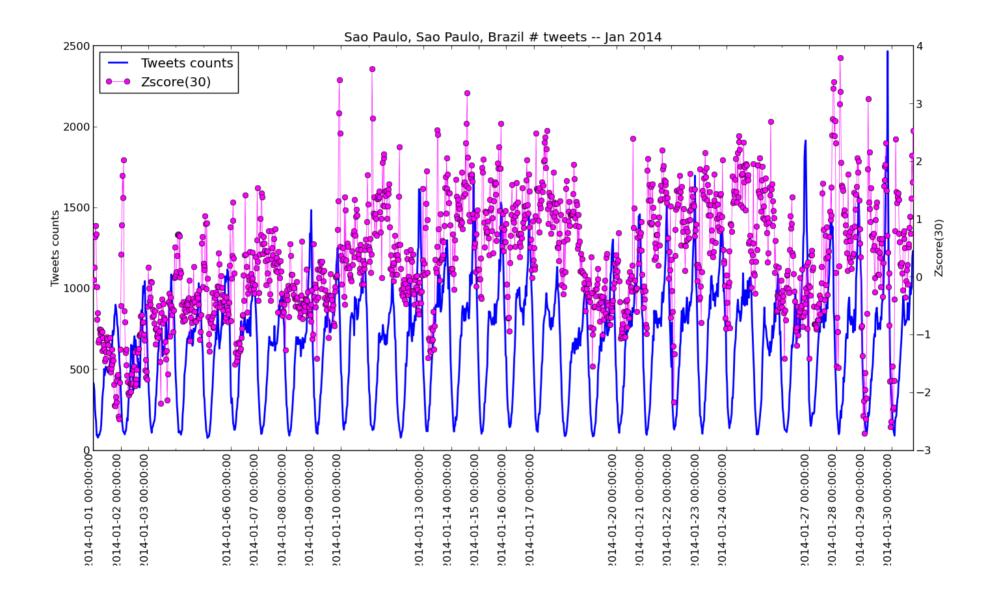


Chile Iquique earthquake on 2014-04-01

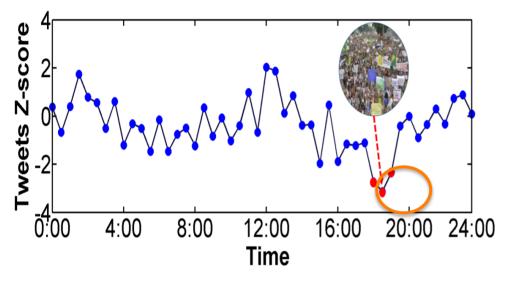


#### Argentina, Christmas holiday on 2015-12-25

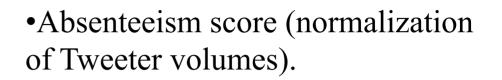
#### Absenteeism score



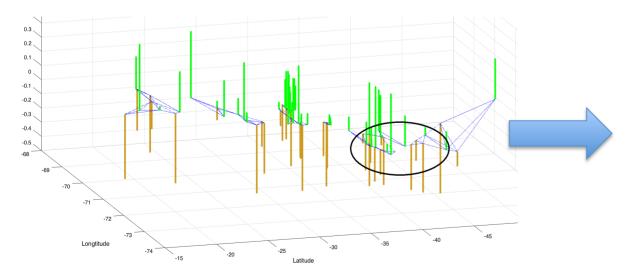
# Motivation



Natal, Brazil protest began at 18 PM on June 17, 2013



•Absenteeism score vector f(n) on graph G.



How to find a group of cities with uniform anomaly?

Absenteeism score distribution vector f(n) on April 1, 2014 in Chile.

# Our approach

- 1. Graph wavelet based approach, considering both the graph structure and the vector f;
- 2. Define an anomaly index of f's distribution on G;
- 3. Identify abnormal locations using graph wavelet;

#### Graph spectrum

Connected, undirected, weighted graph G(V, W; f)

Degree matrix D: zeros except diagonals, which are sums of weights of edges incident to corresponding node

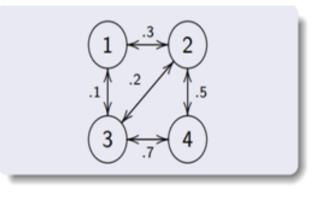
Non-normalized Laplacian: L := D - W

Complete set of orthonormal eigenvectors and associated real, non-negative eigenvalues:

$$L\chi_{l} = \lambda_{l}\chi_{l}$$
  

$$0 = \lambda_{0} < \lambda_{1} \le \lambda_{2} \le \dots \le \lambda_{N-1} := \lambda_{max}$$
  

$$\sigma(\mathbf{G}) := \{(\lambda_{l}, \chi_{l})\}_{l=0}^{N-1} \text{ is graph spectrum.}$$

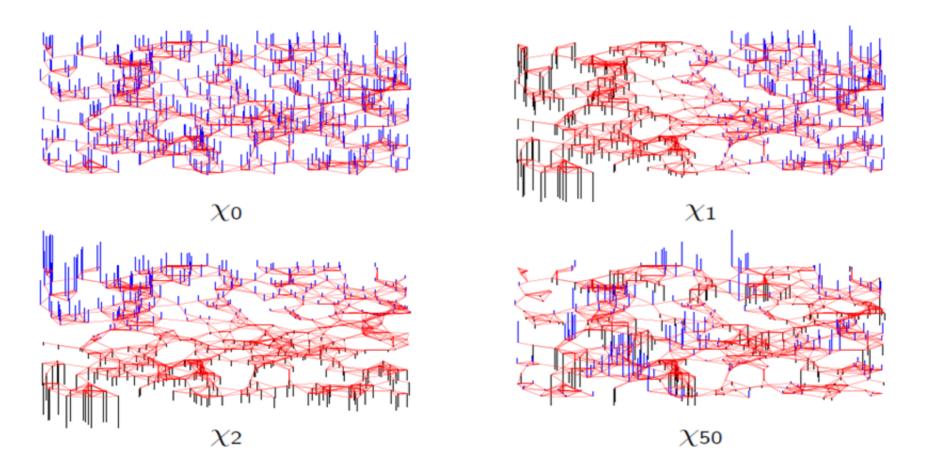


$$W = \left[ \begin{array}{rrrr} 0 & .3 & .1 & 0 \\ .3 & 0 & .2 & .5 \\ .1 & .2 & 0 & .7 \\ 0 & .5 & .7 & 0 \end{array} \right]$$

$$D = \left[ \begin{array}{rrrr} .4 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1.2 \end{array} \right]$$

#### Eigenvalue and eigenvector property (1)

The set of eigenvector represents N types' pattern of graph G



#### The larger eigenvalue corresponds to a severe fluctuation.

Shuman, David I., Benjamin Ricaud, and Pierre Vandergheynst. "A windowed graph Fourier transform." Statistical Signal Processing Workshop (SSP), 2012 IEEE. leee, 2012.

#### Eigenvalue and eigenvector property (2)

f decomposition on the eigenvectors  $\chi_l$ :

$$f(n) = \hat{f}(0)\chi_0 + \dots + \hat{f}(l)\chi_l + \dots + \hat{f}(N-1)\chi_{N-1}$$

$$= \begin{pmatrix} <\chi_{0}, f > \\ <\chi_{1}, f > \\ <\chi_{2}, f > \\ \dots \\ <\chi_{N-1}, f > \end{pmatrix}$$

f

- 1)  $\chi_0, \chi_1, \chi_2, ..., \chi_{N-1}$ : N types of pattern for any vector f defined on graph G.
- 2) For larger  $\lambda_l$ ,  $\chi_l$  has larger vibration.

$$\lambda_l = \chi_l^T \lambda_l \chi_l = \sum_{e_{mn} \in E} w_{mn} [\chi_l(m) - \chi_l(n)]^2$$

3)  $\hat{f}(l)$  represents the similarity of  $\chi_l$  and f.

#### Anomaly index on graph

1. Define the eigenvector  $\chi_l$  anomaly index:

$$\gamma_f(l; \mathbf{G}) = \lambda_l \hat{f}^2(l) = \lambda_l < f, \chi_l >^2$$

2. Define the global anomaly index of f on G:

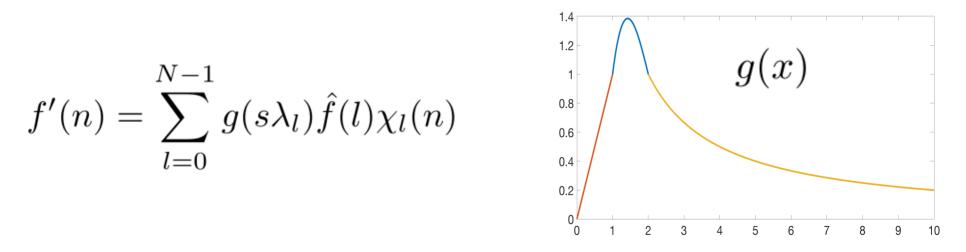
$$\gamma_f(\mathbf{G}) = \max_{0 \le l \le N-1} \gamma_f(l; \mathbf{G})$$

γ<sub>f</sub>(G) depends on two parts:
(1) the eigenvalue which reflects the deviations of χ<sub>l</sub>;
(2) the |f̂(l)|<sup>2</sup> which represents the power of χ<sub>l</sub> in f.

#### Graph wavelet construction

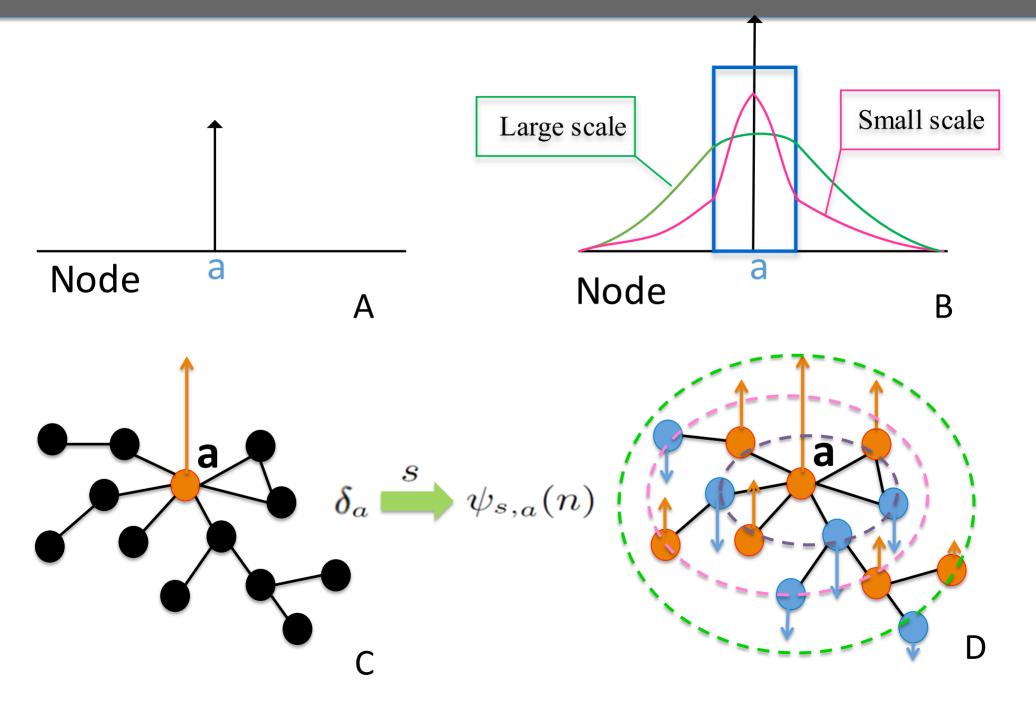
$$f(n) = \sum_{l=0}^{N-1} \hat{f}(l)\chi_l(n)$$

g(x) is a kernel function, which can be treated as a filter, so the original f(n) now become f'(n):



When  $f(n) = \delta_a(n)$ , f'(n) is written as  $\psi_{s,a}(n)$ , we call it graph wavelet.

#### Graph wavelet property (1)



#### Graph wavelet coefficient

The wavelet coefficients for f can be defined as:

$$W_f(s,a) = \langle \psi_{s,a}, f \rangle = \sum_{l=0}^{N-1} g(s\lambda_l) \hat{f}(a) \chi_l(n)$$

 $W_f(s, a)$  is a constant, the largest  $W_f(s, a)$  means high similarity between f and  $\psi_{s,a}$ , means f's energy focus on the area centered around  $v_a$ , with scale s.

f(n) can be recovered by the wavelet coefficients:

$$f(n) = \sum_{s=1}^{j} \sum_{a=1}^{N} W_f(s, a) \cdot \psi_{s,a}(n)$$

# Graph wavelet property (2)

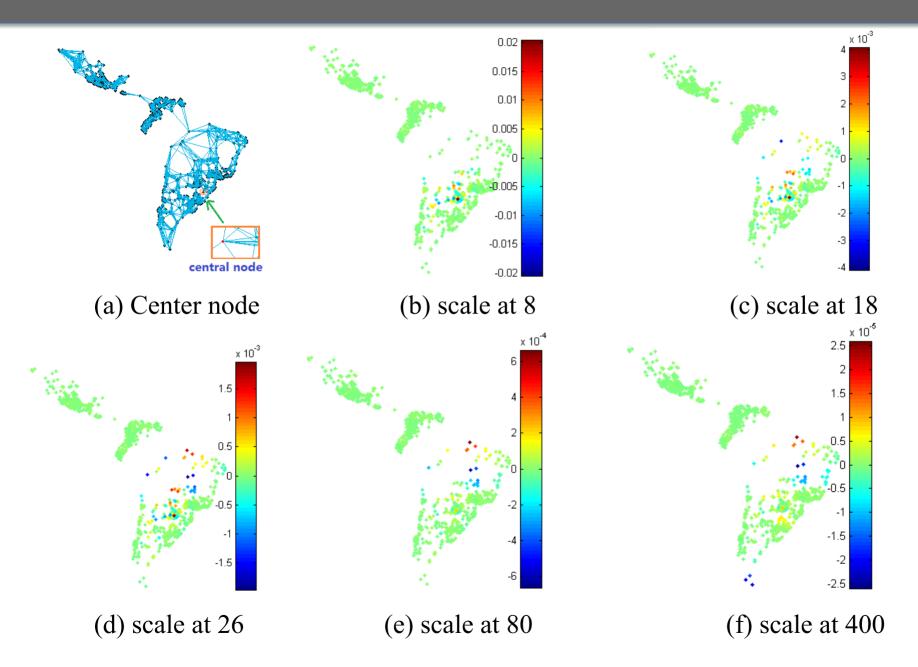
Localization in vertex domains. Given a central vertex  $v_a$  and its graph wavelet  $\psi_{s,a}(n)$ , let  $v_n$  be an vertex of **G** with  $d_G(n, a) > K$ , then there exist constants D and  $\beta$ , such that

 $\frac{|\psi_{s,a}(n)|}{||\psi_{s,a}||} \le Ds$ 

for vertex  $v_n$  which is far away form vertex  $v_a$ , its wavelet value is linearly attenuated by scale s.

g is K + 1 times continuous differentiable.  $d_G(n, a)$  is the is the minimum number of edges that connect vertices  $v_n$  and a.

#### Graph wavelet scale example



Spectral graph wavelet on South America graph.

# Experiment design

Data Source

- Sold standard report (GSR) protests in Latin American countries
- ▶ 10% random sampled twitter data, from Jul. 2012 to Dec. 2014

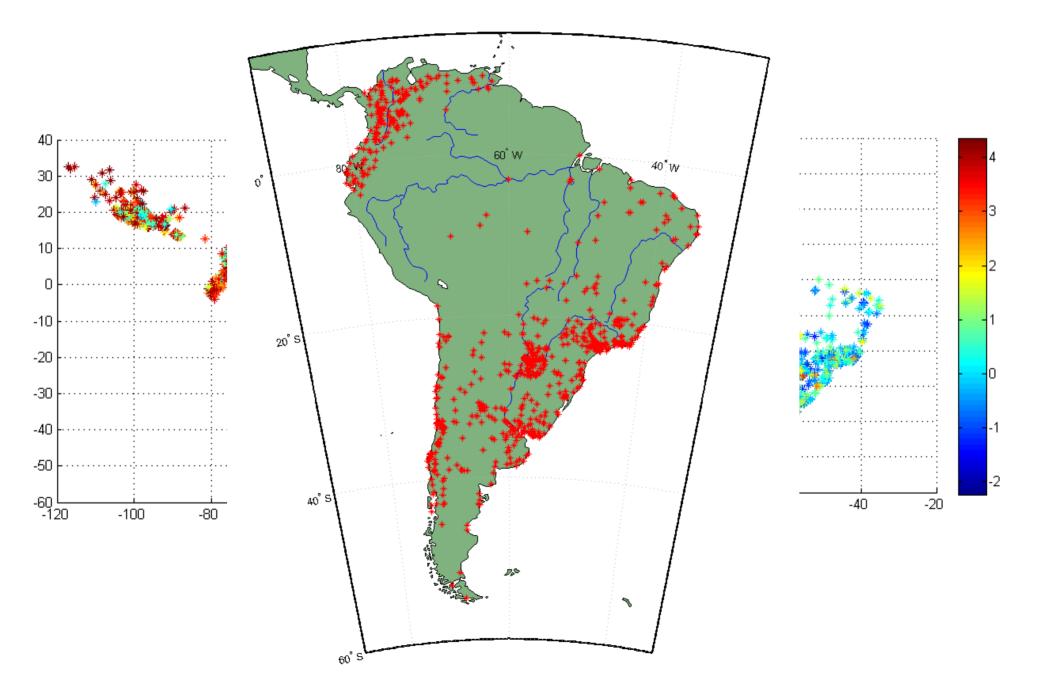
Implementation

- Build graph G for each country, based on KNN
- Compute f(n) based on each city's absenteeism score (Zscore30)
- Calculate anomaly index of f on G
- Set the wavelet coefficient threshold, find the central node and its kernel cities.

Comparison criteria

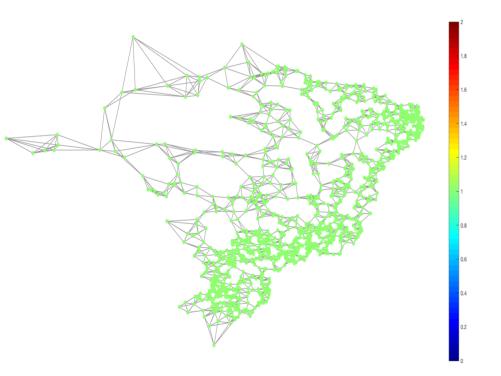
- $\succ$  Event date
- Location (city)
- Group size (group anomaly cities)
- Protest or not

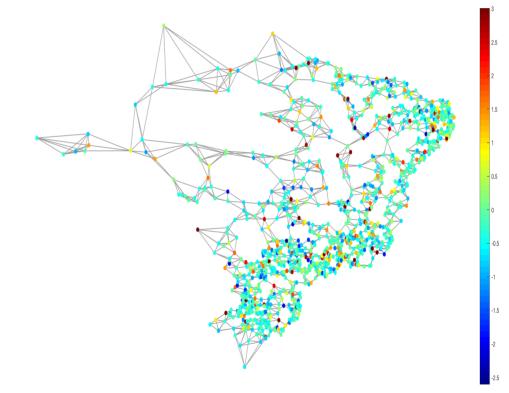
#### Experiment dataset



# Experiment implementation (1)

- 1. Build graph G, based on KNN, set K = 5.
- 2. Compute f(n) based on each city's absenteeism score (Zscore30)



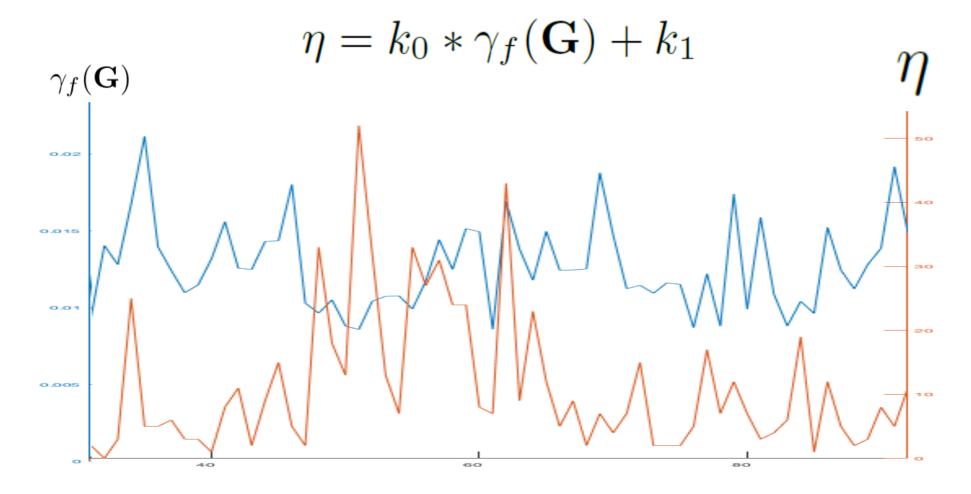


Brazil 5 nearest-neighbor Graph: 1276 cities with all edge weights are 1.

Brazil absenteeism score distribution on June 1st, 2013

#### Experiment implementation (2)

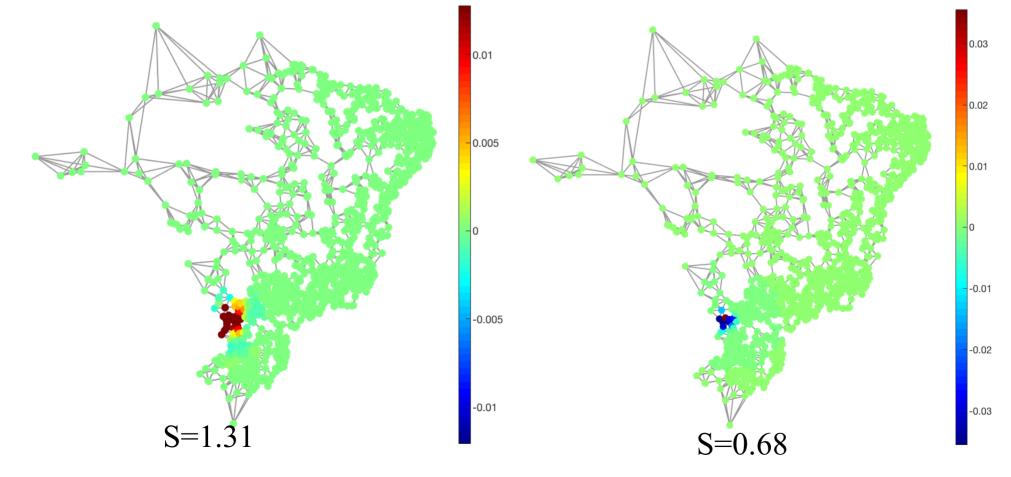
3. We assume anomaly index  $\gamma_f(\mathbf{G})$  has linear relationship with protest events  $\eta$ :



Train historical dataset to get the  $k_0$  and  $k_1$ 

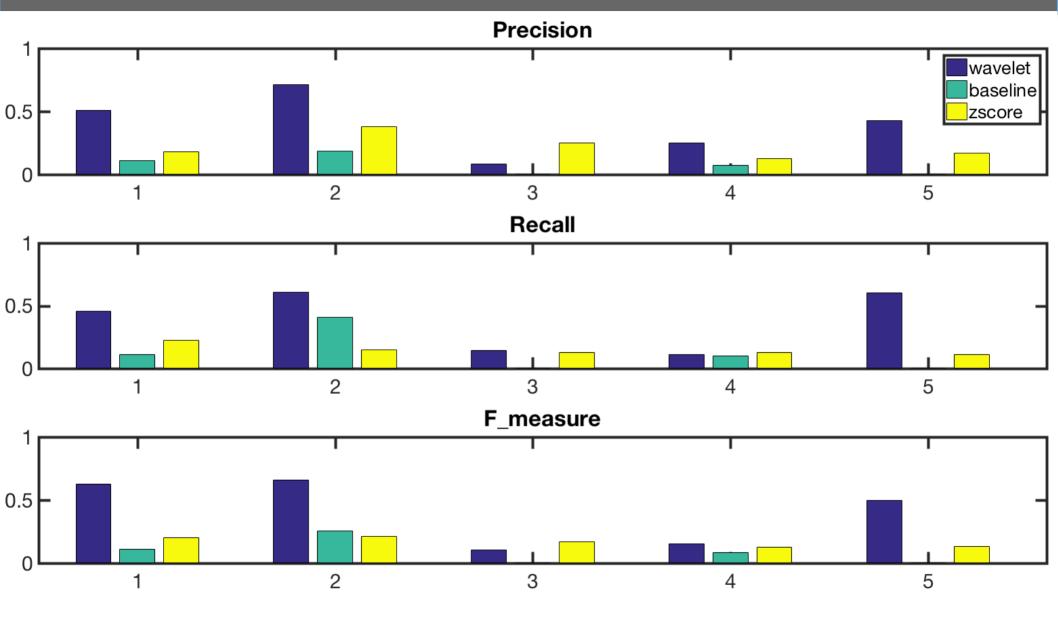
# Experiment implementation (3)

- 4. Calculate wavelet coefficient  $W_f(s, a)$  for each node a with different scale s.
- 5. Select top  $\eta$  wavelet coefficient with scale s, and center a.



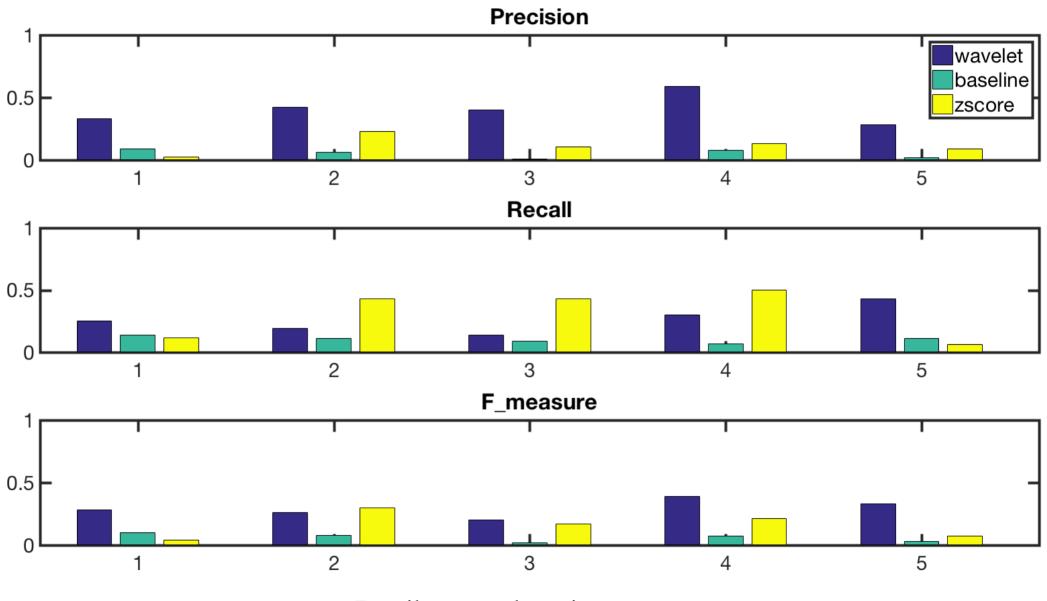
Two graph wavelet with different scale s

#### Experimental results: Mexico protests



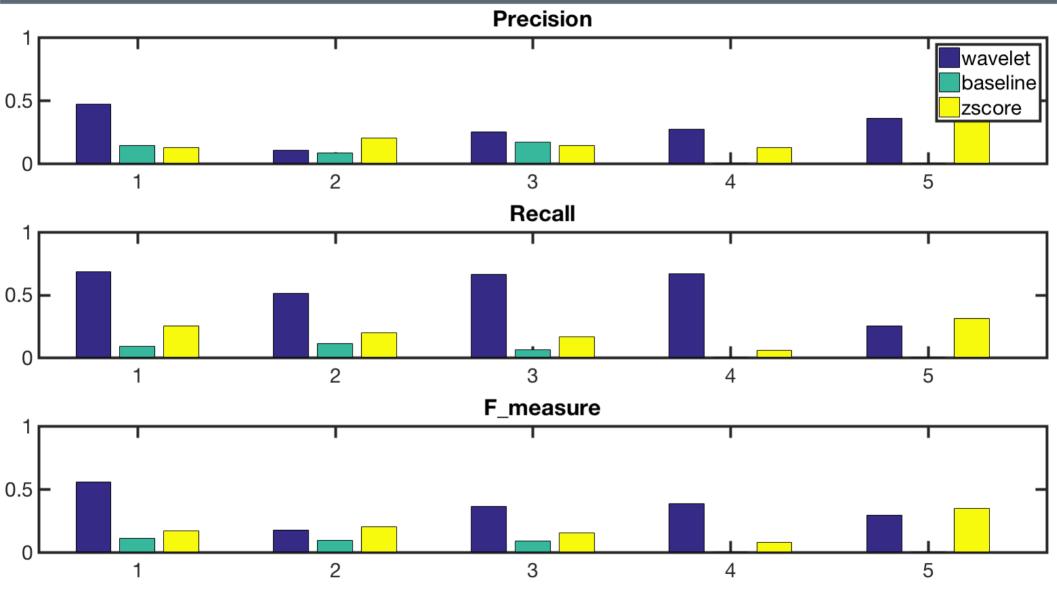
Mexico protest detection performance

#### Experimental results: Brazil protests



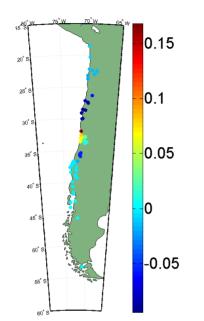
Brazil protest detection

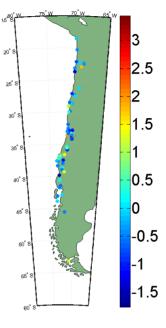
#### Experimental results: Venezuela protests



Venezuela protest detection performance

#### Case study: Chile Earthquake





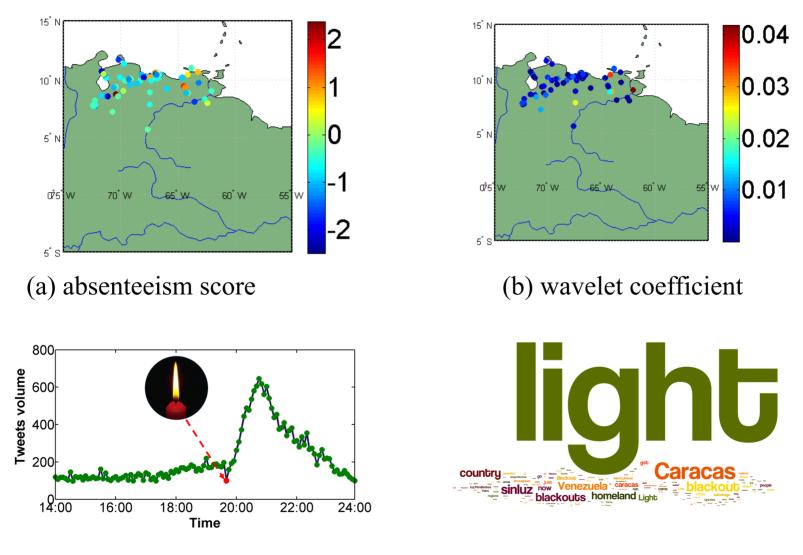
(a) absenteeism score

(b) wavelet coefficient



Iquique Earthquake, Chile. April 1, 2014.

#### Case study: Venezuela Power Outage

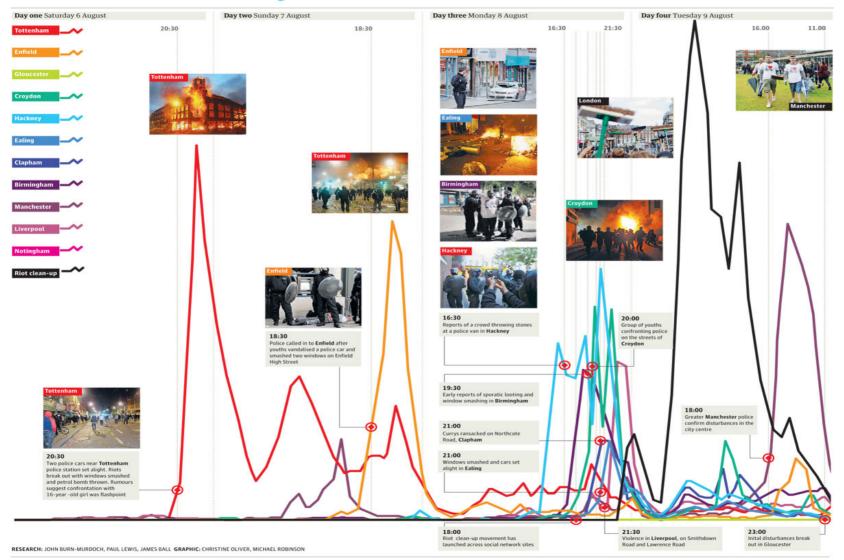


Venezuela power outage. Dec 2, 2013.

#### **Civil Unrest Forecasting**

#### Twitter and the rioting

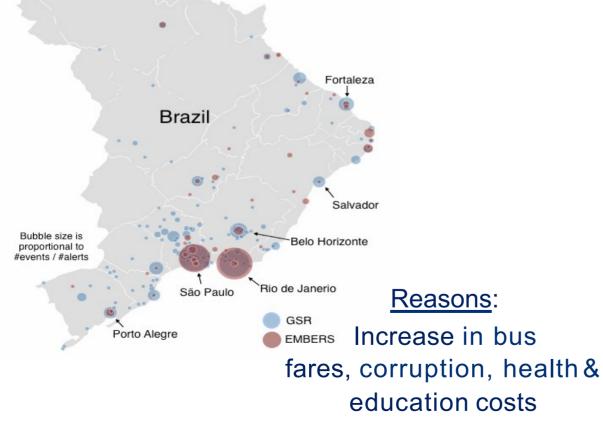
#### **Behind the curve Twitter and the rioting**



#### Protest forecasting

- Focus on 10 Middle and South American countries
- > Forecast who, where, when and why

In **June 2013** countrywide protests erupted in Brazil, also known as the **Vinegar Movement** 



Distribution of civil unrest events in Latin America (Nov'12 -- Aug'14) as per Gold\_Standard Report\*



#### How to forecast protests?



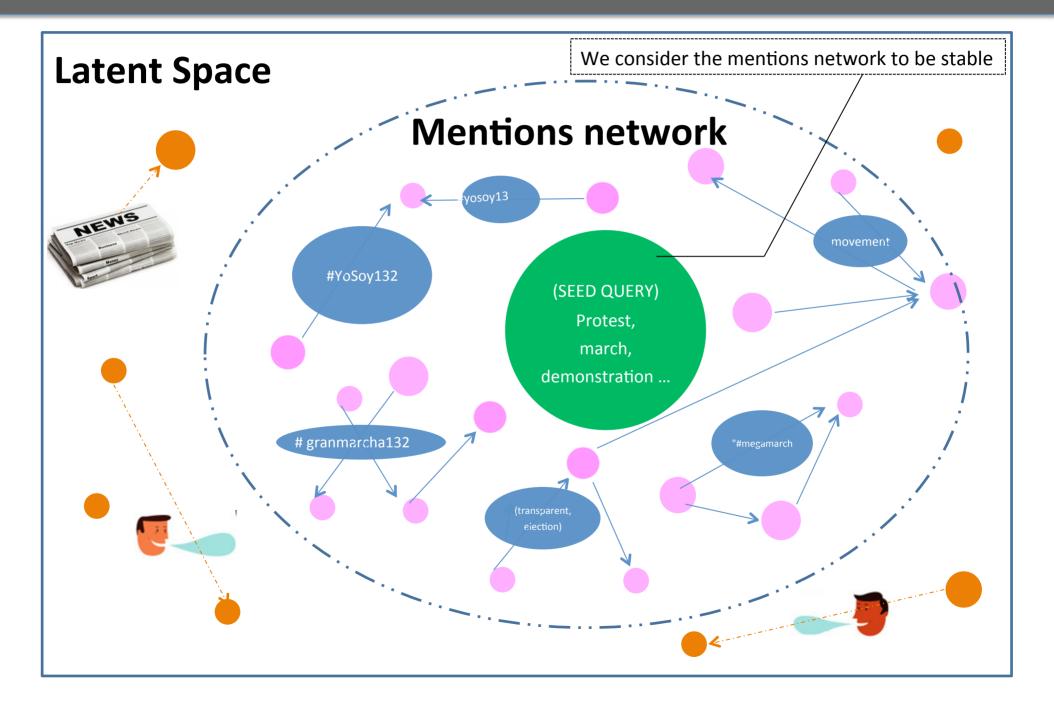
#### #Yosoy132 Protest – Mexico, 2012

#### How to forecast protest?

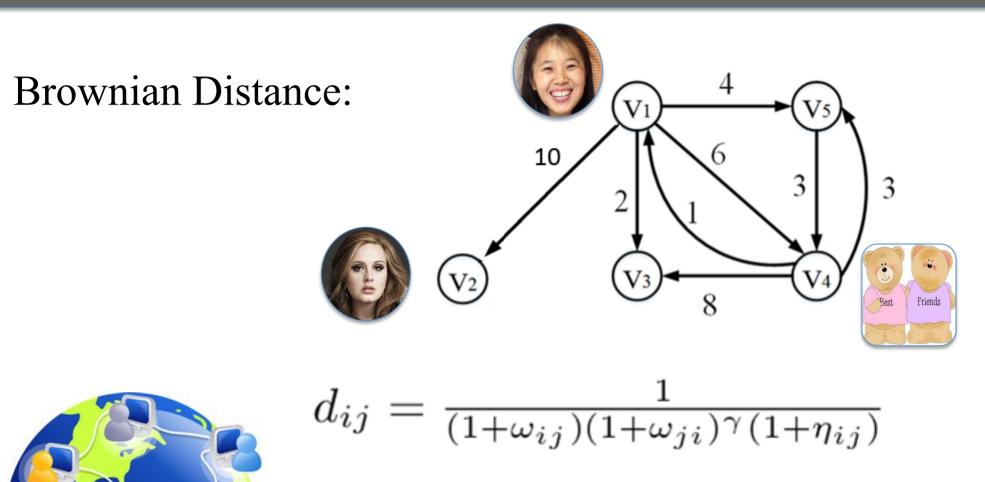
#### Objective:

- Model the recruitment of protest participants within social networks
- Capture the underlying social network and structural dynamics
- Forecast the speed and scale of civil unrest events

# Approach: Bi-space model



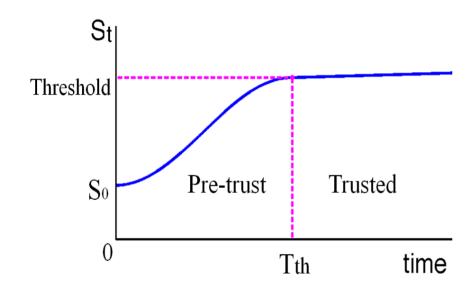
# Propagation in the mentions network (1)



- >  $\omega_{ij}$ : frequency  $v_i$  mentions  $v_j$
- ▶  $\gamma \geq 1$ : higher weight of  $\omega_{ji}$
- >  $\eta_{ij}$ : common neighbors

# Propagation in the mentions network (2)

> Trust function  $S^{ij}(t)$ : How much does user  $v_j$  trust user  $v_i$  at time t ?

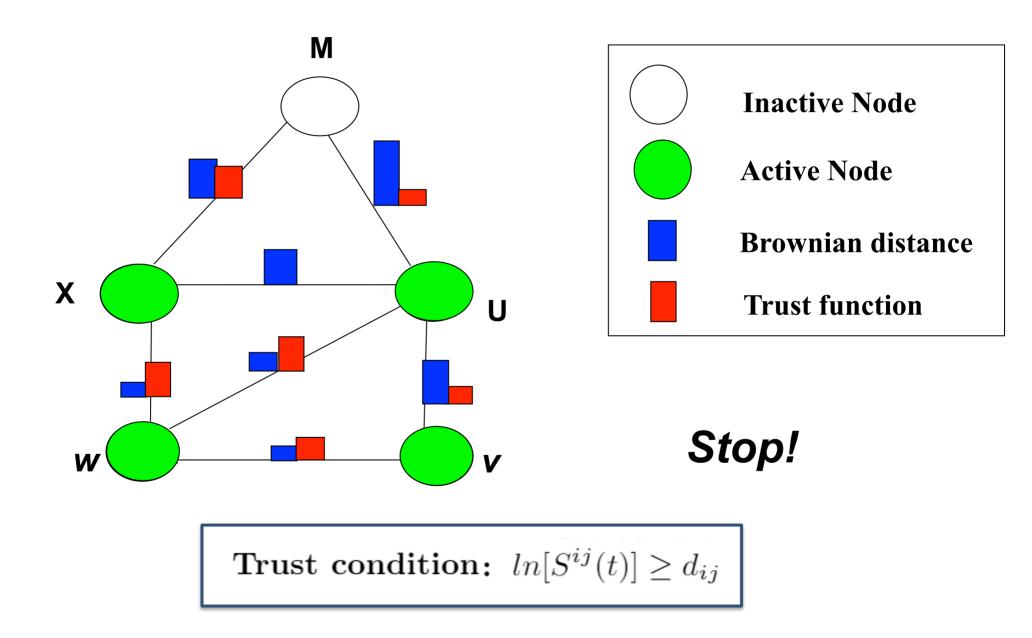


Geometric Brownian motion (GBM)

$$S_t = S_0 \exp\left(\left(\mu - \frac{\sigma^2}{2}\right)t + \sigma W_t\right)$$

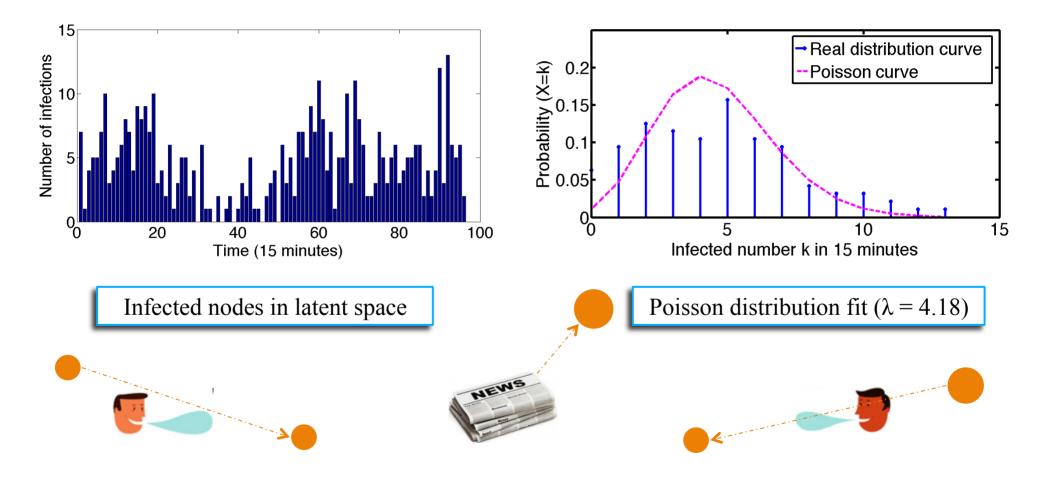
- $\blacktriangleright \quad S^{ij}(t) \sim GBM(\mu, \sigma^2, t)$
- > Trust condition:  $ln[S^{ij}(t)] \ge d_{ij}$

# Propagation in the mentions network (3)



#### Latent space: Poisson distribution

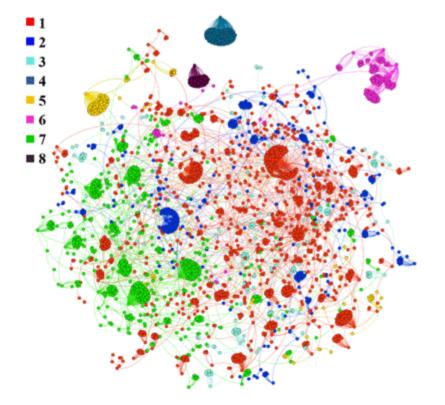
$$\Pr(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

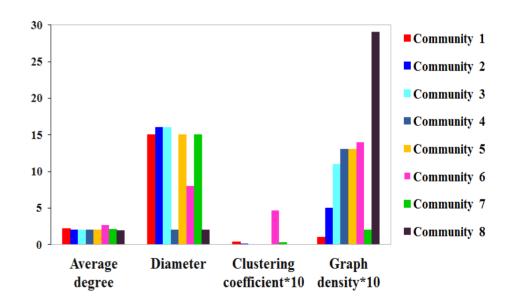


#### Community level propagation

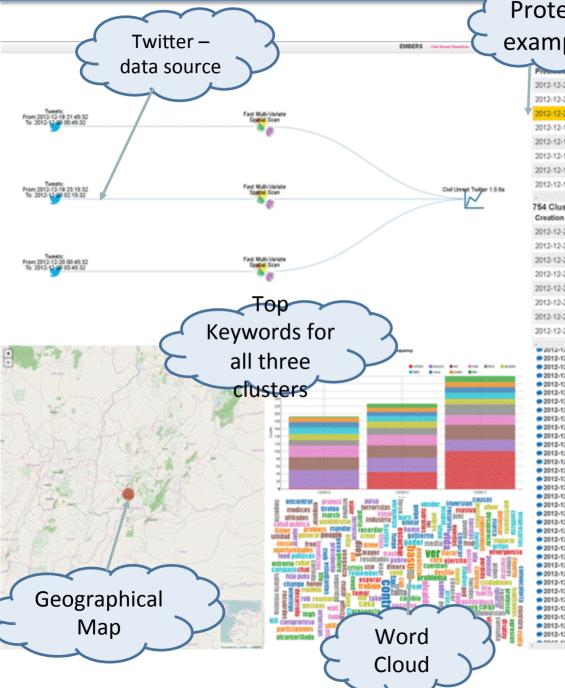
Assumptions:

- > Each community has its own parameters
- Propagation among communities using source community's parameters



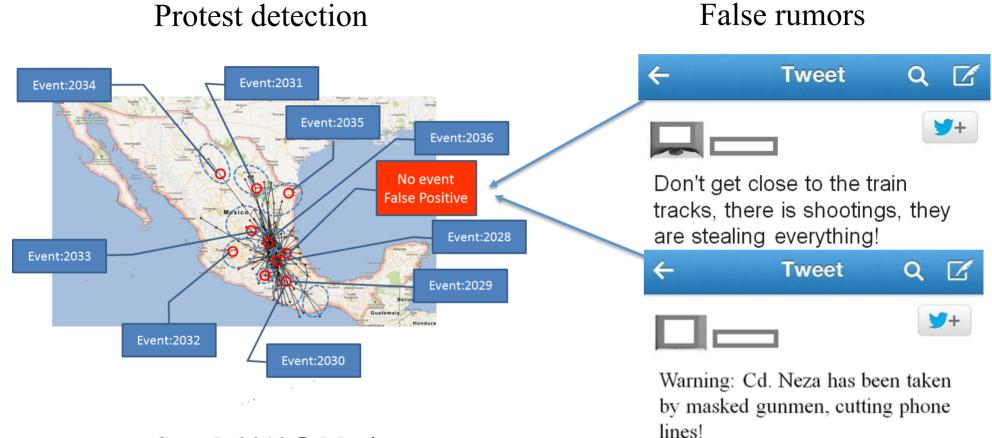


#### Protest forecasting



2012-12-20         2012-12-21         Argentina, Rio Negro, Bariloche         General Population         0141           2012-12-20         2012-12-21         Ecuador, Pichincha, Quito         General Population         0142         2         3         4         5         0	Di Dista da di	E and Data and	l and an an		Providelland			20		195-1		cem	
2012-12-20       2012-12-21       Ecuador, Pichincha, Quito       General Population       0142         2012-12-20       2012-12-20       Brazil, Dirthör Federal, Brazilla       General Population       0142         2012-12-18       2012-12-20       Brazil, Dirthör Federal, Brazilla       General Population       0142         2012-12-18       2012-12-19       Ecuador, Carchi, Tulcán       Education       0122         2012-12-18       2012-12-19       Ecuador, Naço, Tena       Education       0122         2012-12-18       2012-12-19       Ecuador, Richincha, Quito       Education       0122         2012-12-18       2012-12-19       Ecuador, Richincha, Quito       Education       0122         2012-12-18       2012-12-19       Ecuador, Richincha, Quito       Education       0122         2012-12-20       2017-55       General Population       Venezuela       0142         2012-12-20       2017-14       General Population       Venezuela       0142         2012-12-20       2017-14       General Population       Argentina       0142         2012-12-20       2017-14       General Population       Argentina       0142         2012-12-20       2017-14       Agricultural       Colombia       0142	President Date	Event Date-	Location		Population	Event Type		210		TU	Yre		PI
2012-12-20         2012-12-21         Colombia. Bogola. Bogola         Agroubural         0142           2012-12-19         2012-12-20         Brazil, Distrito Federal, Brazilia         General Population         0142           2012-12-18         2012-12-19         Ecuador, Carchi, Tulcian         Education         0122           2012-12-18         2012-12-19         Ecuador, Carchi, Tulcian         Education         0122           2012-12-18         2012-12-19         Ecuador, Rongo, Tena         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           2012-12-20         2017.55         General Population         Venezuela         0142         0141         12           2012-12-20         20.17.50         General Population         Venezuela         0142         0142         0141         12         16         17         18         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2         2								-	-	-	-	-	į.,
2012-12-19       2012-12-20       Brazil, Distrito Pederal, Brazilia       General Population       0142         2012-12-18       2012-12-19       Ecuador, Carchi, Tulcán       Education       0122         2012-12-18       2012-12-19       Ecuador, Tungurahua, Ambato       Education       0122         2012-12-18       2012-12-19       Ecuador, Napo, Tena       Education       0122         2012-12-18       2012-12-19       Ecuador, Pichincha, Quito       Education       0122         2012-12-18       2012-12-19       Ecuador, Pichincha, Quito       Education       0122         2012-12-20       2017-58       General Population       Venezuela       0142         2012-12-20       2017-50       General Population       Venezuela       0142         2012-12-20       2017-50       General Population       Venezuela       0142         2012-12-20       2017-14       General Population       Venezuela       0142         2012-12-20       2017-14       General Population       Argentina       0142         2012-12-20       2017-14       General Population       Paraguay       0142         2012-12-20       2017-14       Agricultural       Colombia       0142         2012-12-20       2017-14							-8		3	4	0	6	-
2012-12-18         2012-12-19         Ecuador, Carchi, Tuicán         Education         0122           2012-12-18         2012-12-19         Ecuador, Tungurahua, Ambato         Education         0122           2012-12-18         2012-12-19         Ecuador, Napo, Tena         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           2012-12-20         2017-50         General Population         Ecuador         0142         0142           2012-12-20         2017.50         General Population         Venezuela         0142         0142         0142         01412         0142         01412         01412         01412         01412         0131         0142         01412         0131         0142         0131         0142         0131         0142         0131         0141         0131         0131         0142         0131         0141         0131         0142         0131         0141         0131         0141         0131         0131         0131         0131         0131         0131         0131         0131         0131         0131							-3	9	10	11	12	13	14
2012-12-18         2012-12-19         Ecuador, Tungurahua, Ambato         Education         0122           2012-12-18         2012-12-19         Ecuador, Napo, Tena         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           2012-12-18         2012-12-19         Ecuador, Pichincha, Quito         Education         0122           754         Clusters         Country-N         Event Type-N         Start           2012-12-20         20.17.58         General Population         Venezuela         0142         9         10         11         12         3         4         5         9         10         11         12         3         4         5         9         10         11         12         3         4         5         9         10         11         12         3         4         5         9         10         11         12         3         4         5         9         10         11         12         3         14         23         2         2         3         4         5         9         10         11         10         11         10         11         12         3<								16	17	18	19	20	21
2012-12-18       2012-12-19       Ecuador, Napo, Tena       Education       0122         2012-12-18       2012-12-19       Ecuador, Pichincha, Quito       Education       0122         754 Clusters       Creation Date-\view       Population.\view       Country-\view       Event Type.\view         2012-12-20 20 17-58       General Population       Ecuador       0142       2       3       4       5       6         2012-12-20 20 17-59       General Population       Venezuela       0142       2       3       4       5       7       19       2       3       4       5       7       19       11       12       3       2       3       4       5       7       10       11       2       3       4       5       7       10       19       2       3       4       5       7       10       19       2       3       4       5       7       10       11       12       3       14       10       11       12       13       16       17       10       19       2       3       3       16       17       10       19       2       3       3       16       17       10       12       2 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>													
2012-12-18       2012-12-19       Ecuador, Pichincha, Quito       Education       0122       4       Start         754 Clusters				vmbato									
754 Clusters       2012       Decer         Creation Date×       Population×       Country×       Event Type×         2012-12-20 20:17:56       General Population       Ecuador       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:41       General Population       Argentina       0142         2012-12-20 20:17:41       General Population       Argentina       0142         2012-12-20 20:17:41       General Population       Paraguay       0142         2012-12-20 20:17:41       General Population       Paraguay       0142         2012-12-20 20:17:14       Agricultural       Colombia       0142         2012-12-20 20:17:14       Agricultural       Colombia       0142         2012-12-20 20:17:14       Agricultural       Colombia       0142         2012-12-19 21:46:26:ERT Gengomezmantnez: A los que vistan a Bogda por estas fochas les pedimos excusas por tener un access tan inepto. #RevocatoriaPetro?         2012-12-19 21:46:36: RT Gengomezmantnez: A los que vistan a Bogda por estas fochas les pedimos excusas por tener un access tan inepto. #RevocatoriaPetro?         2012-12-19 21:46:36: RT Gengomezmantnez: A los que vistan a Bogda por estas fochas les pedimos excusas por tener un acc			11 h						(m		Sta	rt.	
Creation Date>>       Population>>       Country>>       Event Type>>         2012-12-20 20:17:58       General Population       Ecuador       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:41       General Population       Argentina       0142         2012-12-20 20:17:41       General Population       Paraguay       0142         2012-12-20 20:17:14       General Population       Paraguay       0142         2012-12-20 20:17:14       Agricultural       Colombia       0142         2012-12-20 20:17:14       Agricultural       Colombia       0142         2012-12-19 21:46:12: GualeLucerkina jajaja cele no me digas tonta que estoy subceptole : necesto MARAR A ALGUIEN >> #Uxeb jajagajaja buscame a algule       2012-12-19 21:46:12: GualeLucerkina jajaja cele no me digas tonta que estoy subceptole : necesto MARAR A ALGUIEN >> #Executa jajagajajaja buscame a algule         2012-12-19 21:46:12: GualeLucerkina jajaja cele no me digas tonta que estoy subceptole : necesto MARAR A ALGUIEN >> #Executa jajagajajaja buscame a algule         2012-12-19 21:46:12: GualeLucerkina jajaja cele no me digas tonta que estoy subceptole : necesto MARAR A ALGUIEN >> #Executa jajagajajaja buscame a lagule	2012-12-18	2012-12-19	Ecuador, Pichincha, Qui	10	Education	0122	-	20	12		De	cem	ber
2012-12-20 20:17:58       General Population       Ecuador       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:50       General Population       Venezuela       0142         2012-12-20 20:17:41       General Population       Argentina       0142         2012-12-20 20:17:18       General Population       Paraguay       0142         2012-12-20 20:17:14       Agricultural       Colombia       0122         2012-12-19 21:46:12       GialeLuceFilin ajajaja       auscente a algule         2012-12-19 21:46:36: RT @momezmatrine: A los que vistan a Bogota por estas fichas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:36: RT @momezmatrine: A los que vistan a Bogota por estas fichas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:36: RT @momzmatrine: A los que vistan a Bogota por estas fichas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:46: RT @mo	754 Clusters							8u	Mo	Tu	We	Th	Ft
2012-12-20 20 17:50       General Population       Venezuela       0142         2012-12-20 20 17:50       General Population       Venezuela       0142         2012-12-20 20 17:51       General Population       Argentina       0142         2012-12-20 20 17:11       General Population       Argentina       0142         2012-12-20 20 17:13       General Population       Paraguay       0142         2012-12-20 20 17:14       Agricultural       Colombia       0142         2012-12-19 21:46:25       Callelu-ceRin an ome digas torna que estoy susceptole (necesto MARAR A ALGUEN ~~ BUKol jajagiaja buscame a algue         2012-12-19 21:46:26       RT @momematrinez: A los que vistan a Bogota por estas fechas les pedimos excuras por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @momematrinez: A los que vistan a Bogota por estas fechas les pedimos excuras por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @momematrinez: A los que vistan a Bogota por estas fechas les polimos excuras por tener un alcalde tan inepto. #RevocatoriaPe	Creation Date	Pop	pulation	Country	Even	t Type~~	1						
2012-12-20 20.17:50       General Population       Venezuela       0142         2012-12-20 20.17:41       General Population       Argentina       0142         2012-12-20 20.17:41       General Population       Argentina       0142         2012-12-20 20.17:14       General Population       Paraguay       0142         2012-12-20 20.17:14       Agricultural       Colombia       0122         2012-12-19 21:46:12: GLaleLuceRina jajajaja osea no me orgas tonta que estoy susceptible ( necesto MARAR A ALGUIEN ~* BURDI jajajajaja buscame a algule         2012-12-19 21:46:26: RT @gnogenzamatrine: A los que vistan a Bogota por estas fechas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @jnogenzamatrine: A los que vistan a Bogota por estas fechas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @jnogenzamatrine: A los que vistan a Bogota por estas fechas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @jnogenzamatrine: A los que vistan a Bogota por estas fechas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:26: RT @jnoge	2012-12-20 20:17:58	Ger	neral Population	Ecuador	0142								
2012-12-20 20:17.41       General Population       Argentina       0142         2012-12-20 20:17.41       General Population       Paraguay       0142         2012-12-20 20:17.18       General Population       Paraguay       0142         2012-12-20 20:17.14       Agricultural       Colombia       0122         2012-12-20 20:17.14       Agricultural       Colombia       0122         2012-12-19 21:46:12: GLaieLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MARARA A ALGUIEN ** BUcci jajajajaja) buscame a alguée         2012-12-19 21:46:12: GLaieLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MARARA A ALGUIEN ** BUcci jajajajaja) buscame a alguée         2012-12-19 21:46:26: estoy bloqueda tengo un trabaja urgente para el viernes y no he terminado	2012-12-20 20:17:50	Ger	neral Population	Venezuela	0142								
2012-12-20 20:17.41       General Population       Argentina       0142         2012-12-20 20:17.18       General Population       Paraguay       0142         2012-12-20 20:17.14       Agricultural       Colombia       0122         2012-12-19 21:46:12:       GLaikLucenna jajajaja osea no me digas tonta que estoy susceptible : (necesto Manaex A ALGUIEN ~* BUKol jajajajaja) buscame a alguée       2012-12-19 21:46:12:         2012-12-19 21:46:32:       GLaikLucenna jajaja       osea no me digas tonta que estoy susceptible : (necesto Manaex A ALGUIEN ~* BUKol jajajajaja) buscame a alguée         2012-12-19 21:46:32:       GLaikLucenna jajaja       osea no me digas tonta que estoy susceptible : (necesto Manaex A ALGUIEN ~* BUKol jajajajaja)       Buscame a alguée         2012-12-19 21:46:32:       General Population       Bogota por estas fechas les pedinos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:36:       RT @jessicacedie: Cue pesar mi Bogotal Uena de basura y trafico imposible! Como nos duele la capital ©         2012-12-19 21:47:17:18:       RT @jessicacedie: Cue pesar mi Bogotal Uena de basura y trafico imposible! Como nos duele la capital ©         201	2012-12-20 20:17:50	Ger	neral Population	Venezuela	0142						19	20	21
2012-12-20 20.17.41       General Population       Argentina       0142         2012-12-20 20.17.16       General Population       Paraguay       0142         2012-12-20 20.17.16       General Population       Paraguay       0142         2012-12-20 20.17.14       Agricultural       Colombia       0142         2012-12-20 20.17.14       Agricultural       Colombia       0122         2012-12-19 21:46:12: GLaieLuceRina jajajaja osea no me digas tonta que estoy susceptore : necesto MARARY A ALGUIEN → BCkS jajajajaja buscame a alguie         2012-12-19 21:46:12: GLaieLuceRina jajajaja osea no me digas tonta que estoy susceptore : necesto MARARY A ALGUIEN → BCkS jajajajaja buscame a alguie         2012-12-19 21:46:36: RT @mgomezmartinez: A los que vistan a Bogota por estas fechas les pedinos excusas por tener un acade tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:36: RT @mgomezmartinez: A los que vistan a Bogota por estas fechas les pedinos excusas por tener un acade tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:46: RT @jessicacediel: Que pesar mi Bogota Luena de Basura y trafico imposibiel Como nos duele la capital ©         2012-12-19 21:46:46: RT @jessicacediel: Que pesar mi Bogota Luena de Basura y trafico imposibiel Como nos duele la capital ©         2012-12-19 21:47:10: RT @jessicacediel: Que pesar mi Bogota Luena de Basura y trafico imposibiel Como nos duele la capital ©         2012-12-19 21:47:12: RT @jessicacediel: Que pesar mi Bogota Luena de Basura y trafico imposibiel Como nos duele la capital ©	2012-12-20 20:17:41	Ger	neral Population	Argentina	0142			23	24	25	26	27	28
2012-12-20 20.17.18       General Population       Paraguay       0142         2012-12-20 20.17.14       Agricultural       Colombia       0142         2012-12-20 20.17.14       Agricultural       Colombia       0122         2012-12-20 20.17.14       Agricultural       Colombia       0122         2012-12-20 20.17.14       Agricultural       Colombia       0122         2012-12-19 21:46:12:       GlaikLuceRina jajajaja osea no me digas tonta que estoy susceptole 1 necesto MAMARY A ALGUIEN ¬> BCKS jajajajaja buscame a alguie         2012-12-19 21:46:12:       GlaikLuceRina jajajaja osea no me digas tonta que estoy susceptole 1 necesto MAMARY A ALGUIEN ¬> BCKS jajajaja buscame a alguie         2012-12-19 21:46:02:       RevocatoriaPetroY         2012-12-19 21:46:03:       RT @mgomezmatinez: A los que vistan a Bogota por estas techas les pedimos excusas por tener un alcalde tan inepto. #RevocatoriaPetroY         2012-12-19 21:46:03:       RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposibiel Como nos duele la captal ©         2012-12-19 21:46:04:       RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposibiel Como nos duele la captal ©         2012-12-19 21:47:10:       RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposibiel Como nos duele la captal ©         2012-12-19 21:47:10:       RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposibiel Como nos duele la captal ©	2012-12-20 20:17:41	Ger	neral Population	Argentina	0142								-
2012-12-20 20.17.14       Agricultural       Colombia       0142         2012-12-20 20.17.14       Agricultural       Colombia       0122         2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajajajaja buscame a algule       2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajajaja buscame a algule         2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajajaja buscame a algule         2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajajaja buscame a algule         2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajajaja buscame a algule         2012-12-19 21:46:12: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajaja)         2012-12-19 21:46:13: @LaleLuceRina jajajaja osea no me digas tonta que estoy susceptible ( necesto MAAARX A ALGUIEN ~* #Ukoi jajajaja)         2012-12-19 21:46:14: @LaleLuceRina jajajaja       #RevocatoriaPetroY         2012-12-19 21:46:14: @LaleLuceRina jajajaja       #RevocatoriaPetroY         2012-12-19 21:47:10: RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposible! Como nos duele la captal ©         2012-12-19 21:47:10: RT @jessicacediel: Que pesar mi Bogotal Llena de basura y trafico imposible! Como nos duele la capta	2012-12-20 20:17:18	Ger	neral Population	Paraguay	0142			50	91				
2012-12-19 21.46.12. @LaleLucevina jajaja osea no me digas tonta que estoy susceptole ( necesto MARAY A ALGUIEN ** BURGI jajajaja) buscame a alguie     2012-12-19 21.46.12. @LaleLuceVina jajaja osea no me digas tonta que estoy susceptole ( necesto MARAY A ALGUIEN ** BURGI jajajaja) buscame a alguie     2012-12-19 21.46.26. RT @mgomeznatinez: A los que vistan a Bogota por estas fechas les pedimos excusas por tener un alcalote tan inepto. #RevocatoriaPetroY     2012-12-19 21.46.36. estoy bloqueada tengo un tabaja urgente para el viernes y no he terminado {     2012-12-19 21.46.36. estoy bloqueada tengo un tabaja urgente para el viernes y no he terminado {     2012-12-19 21.46.36. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.46.46. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.10. RT @jiSarcasmos: ¿Saben que traera el ano que viene? 365 nuevas portundades     2012-12-19 21.47.10. RT @jiSarcasmos: ¿Saben que traera el ano que viene? 365 nuevas portundades     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.10. RT @jiSarcasmos: ¿Saben que traera el ano que viene? 365 nuevas portundades     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.24. RT @jessicacedei: Que pesar mi Bogota Luena de basura y trañco imposibiel Como nos duele la captal @     2012-12-19 21.47.24. RT	2012-12-20 20:17:14	Agr	icultural	Colombia	0142				[*		12.000	3	
2012-12-19 21:49:02: RT @NoviosDeJovenes: Diez son los mandamentos solo dos me aprendi, uno amar a dos y el otro amarte a b.     2012-12-19 21:49:19: RT @Jessicacediel: Que pesar mi Bogotal Llena ve basura y trafico imposibiel Como nos duele la capital      ©     2012-12-19: 21:49:19: RT @Jessicacediel: Que pesar mi Bogotal Llena ve basura y trafico imposibiel Como nos duele la capital      ©     2012-12-19: 21:49:19: RT @Jessicacediel: Que pesar mi Bogotal Llena ve basura y trafico imposibiel Como nos duele la capital      ©     2012-12-19: 21:49:15: RT @Jessicacediel: Que pesar mi Bogotal Llena ve basura y trafico imposibiel Como nos duele la capital      ©     2012-12-19: 21:49:15: RT @Jessicacediel: Que pesar mi Bogotal Llena ve basura y trafico imposibiel Como nos duele la capital      ©     2012-12-19: 21:50:21: Lo de las volguetas no suena exactamente a <u>implico</u> digno: viola todas las normas de <u>implico</u> en atura y con <u>anto</u> de accidentalidad.	<ul> <li>2012-12-19 21:46:12</li> <li>2012-12-19 21:46:36</li> <li>2012-12-19 21:46:36</li> <li>2012-12-19 21:46:36</li> <li>2012-12-19 21:46:36</li> <li>2012-12-19 21:46:36</li> <li>2012-12-19 21:46:46</li> <li>2012-12-19 21:46:46</li> </ul>	2: @LaleLuceRina jajaja 5: RT @mgomezmartine 5: estoy bloqueada ter 5: RT @mgomezmartine 6: estoy bloqueada ter 5: RT @jessicacediel: Q 5: RT @jessicacediel: Q	ja osea no me digas tonta qu z: A los que visitan a Bogota go un tratago urgente para e z: A los que visitan a Bogota igo un tratago urgente para e ue pesar mi Bogotal Llena de ue pesar mi Bogotal Llena de	ue estoy susceptible por estas fechas i el viernes y no he t por estas fechas i el viernes y no he t e basura y trafico i e basura y trafico i	ie :{ necesito MATAR A es pedimos excusas p terminado :{ es pedimos excusas p terminado :{ mposible! Como nos d mposible! Como nos d	ALGUIEN ~~ #OKSI jaj or tener un alcalde tan i or tener un alcalde tan i uele la capital ()	ajajaj nepto	aja b a, #Ri	evoc	me a atork	alg aPet	uien/ ro'Ya	XD

# Case study: misinformation campaigns

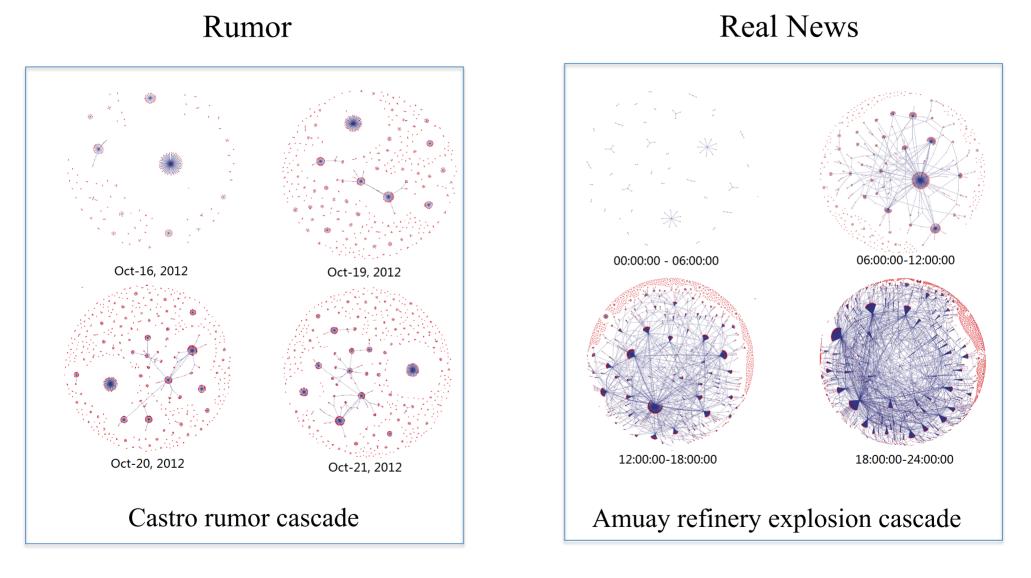


Sept 5, 2012@ Mexico

How can we distinguish real movements from rumors?

#### **Distinguish rumors from real news**

#### Difference between rumor and news propagation



Retweet cascade

#### Model intuition (comparing disease vs rumor propagation)

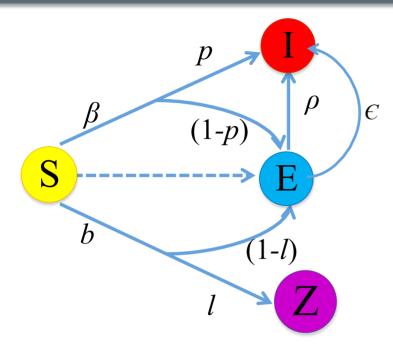
#### Similarities:

- susceptible, using status
- infected, using status
- $\succ$  may take time to accept, exposed status  $\mathbf{E}$
- with transmission route

#### Differences:

- $\succ$  Idea: can be skeptics, introduce skeptics  $\mathbb{Z}$
- Idea: no immune system, no recover "R"

### SEIZ Model

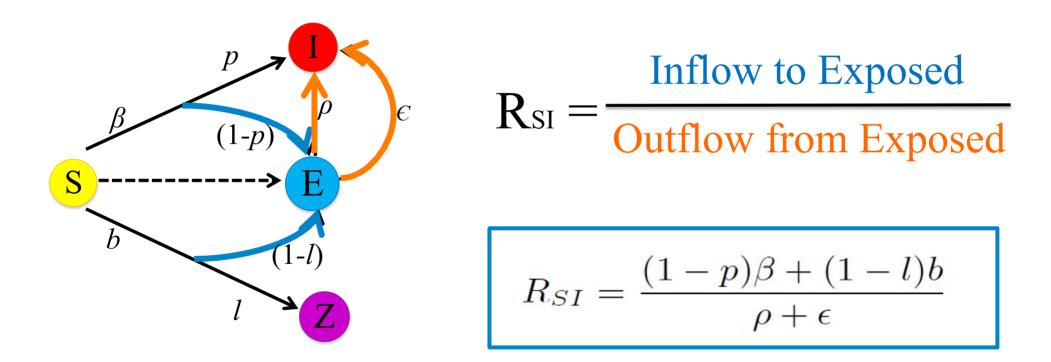


$$\begin{aligned} \frac{d[S]}{dt} &= -\beta S \frac{I}{N} - bS \frac{Z}{N} \\ \frac{d[E]}{dt} &= (1-p)\beta S \frac{I}{N} + (1-l)bS \frac{Z}{N} - \rho E \frac{I}{N} - \epsilon E \\ \frac{d[I]}{dt} &= p\beta S \frac{I}{N} + \rho E \frac{I}{N} + \epsilon E \\ \frac{d[Z]}{dt} &= lbS \frac{Z}{N} \end{aligned}$$

Susceptible	S	Twitter accounts
Infected		Believe news / rumor, (I) post a tweet
Exposed	E	Be exposed but not yet believe
Skeptics	Ζ	Skeptics, do not tweet
Disease		Ideas

# Capturing people's acceptance of ideas

**Response ratio:** Compare the speed of **adding to the Exposed** compartment with removing from the Exposed compartment.



 $R_{SI}$ , a kind of flux ratio, the ratio of effects entering E to those leaving E.

### Dataset: Ebola related rumors

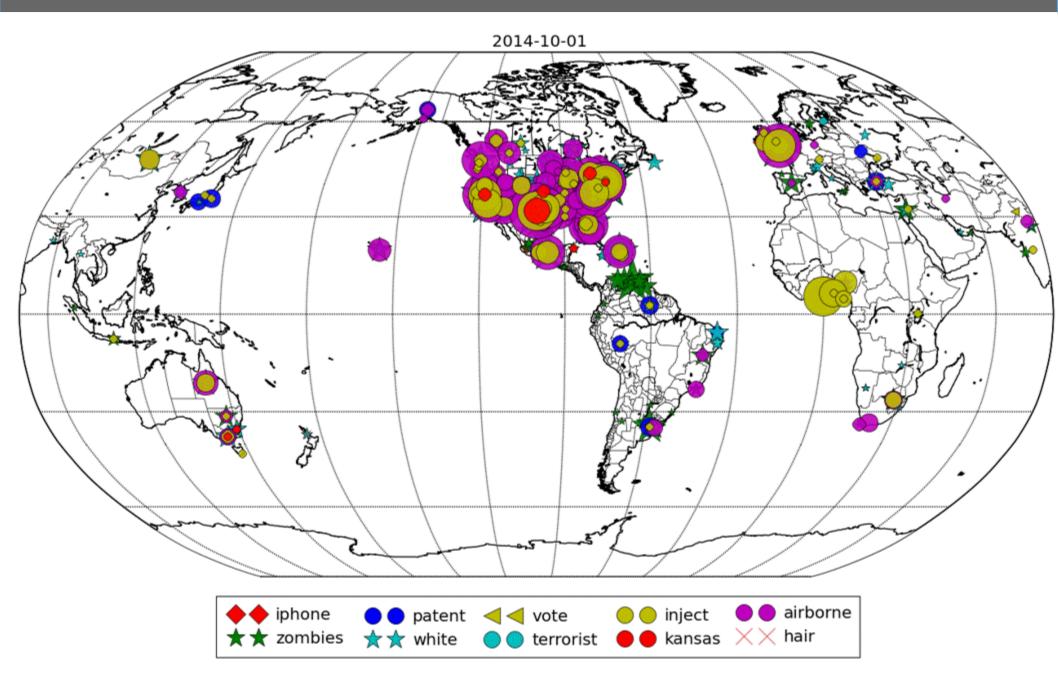
#### Table 1. Top 10 Ebola-related rumors by Tweet volume from 28 September to 18 October 2014.

Rumor no.	Content	Label			
1	Ebola vaccine only works on white people		White		
2	Ebola patients have risen from the dead		Zombie		
3	Ebola could be airborne in some cases         Can you believ			Airborne	
4	Health officials might inject Ebola patients with lethal substance		Inject		
5	There will be no 2016 election and complete anarchy		Vote		
6	The US government owns a patent on the Ebola virus	elieve?	Patent		
7	Terrorists will purposely contract Ebola and spread it around	elieve?	Terrorist		
8	The new iPhone 6 is infecting people with Ebola		iPhone		
9	There is a suspected Ebola case in Kansas City		Kansas		
10	Ebola has been detected in hair extensions		Hair		
Table 2: Ebola related news stories					

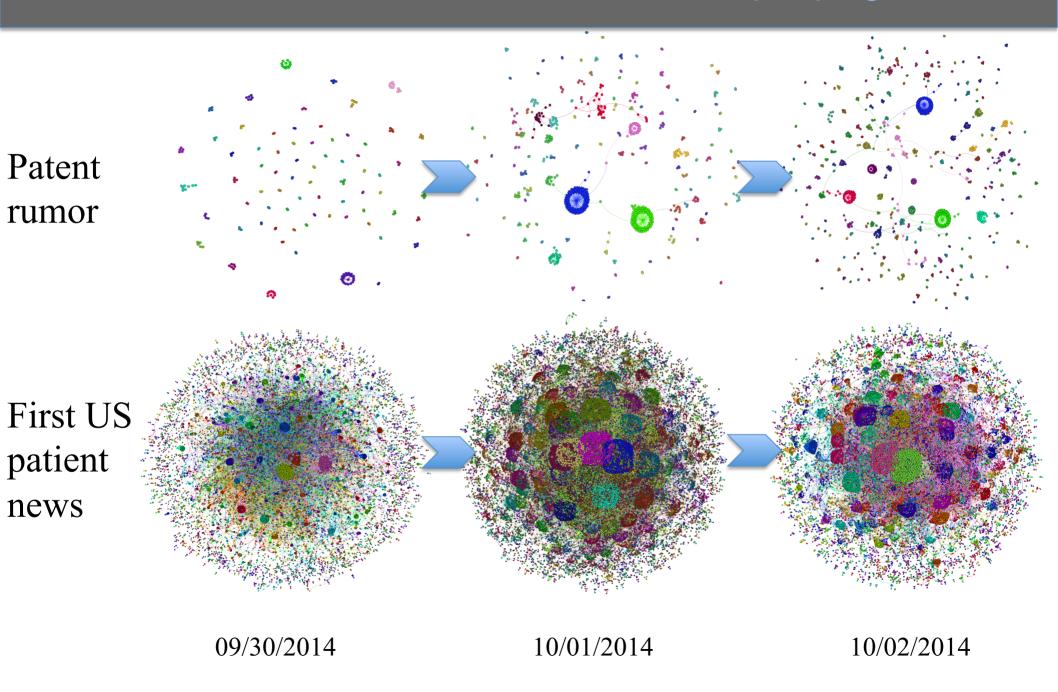
#### L'UUIA ICIAICU IICWS SIULICS

1	The first Ebola patient (Duncan) identified in US (Dallas).	Dallas
2	The specific symptoms and travel activities of Spencer in the days before he was diagnosed.	Spencer
3	The first confirmation of an Ebola patient in New York City	NYC

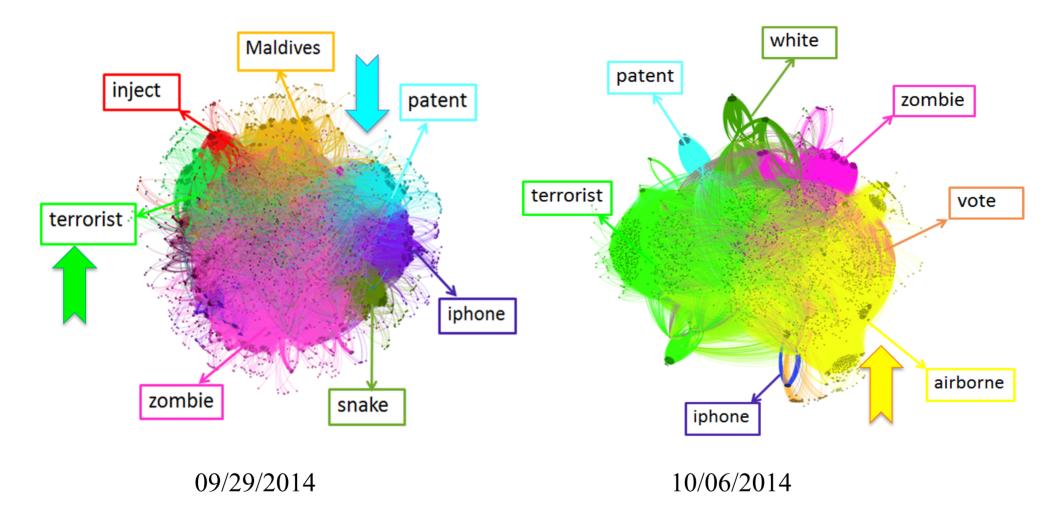
#### Ebola related rumor distribution



#### Difference between rumor and news propagation

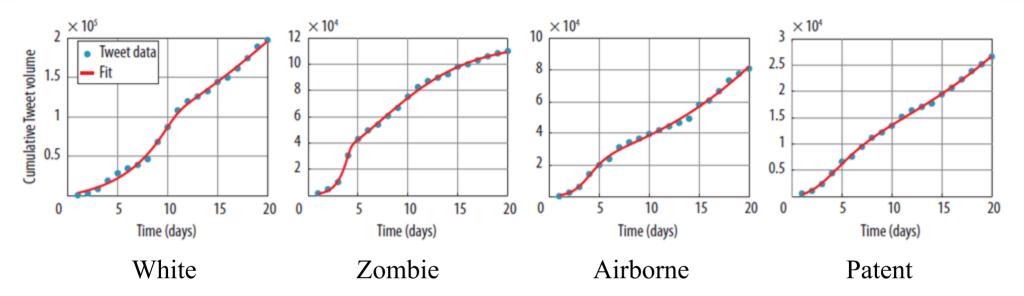


#### Ebola rumors cluster

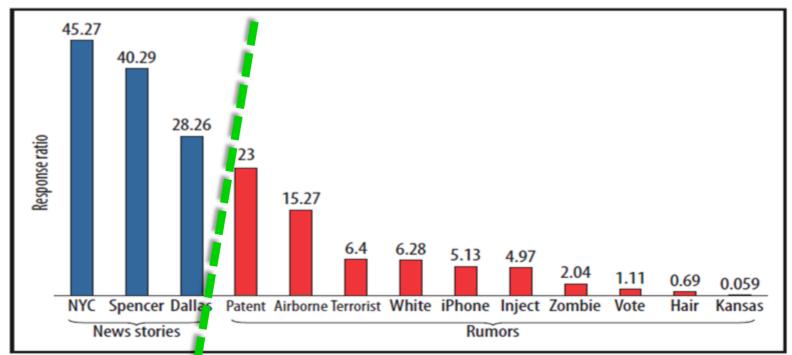


Rumors are color coded consistently across the two frames.

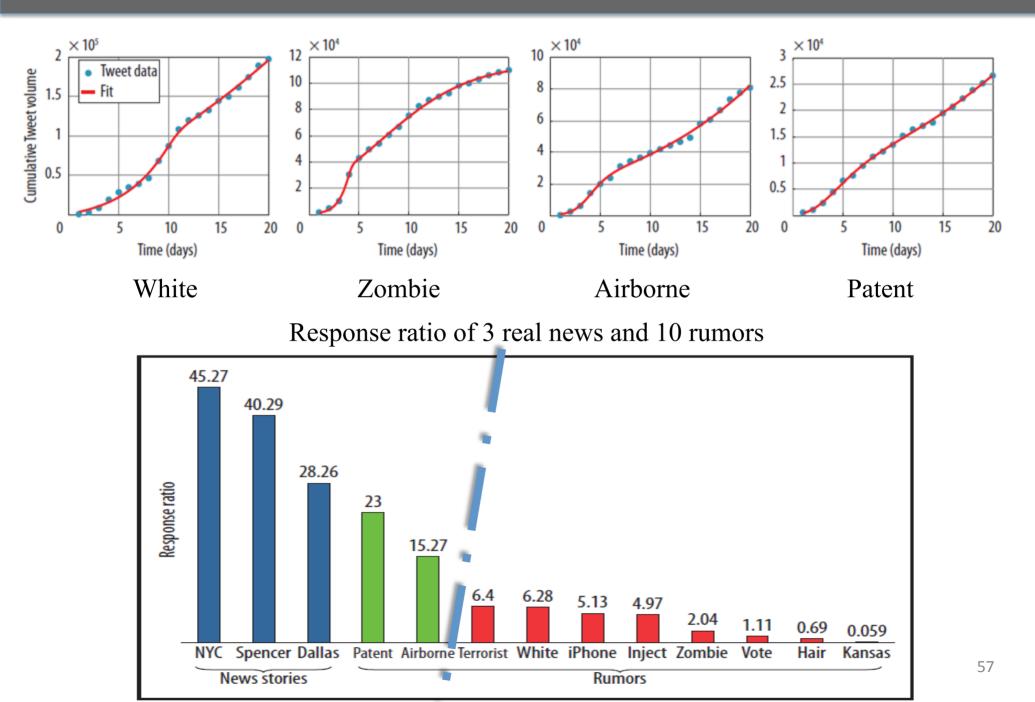
#### SEIZ results of Ebola rumors



Response ratio of 3 real news and 10 rumors



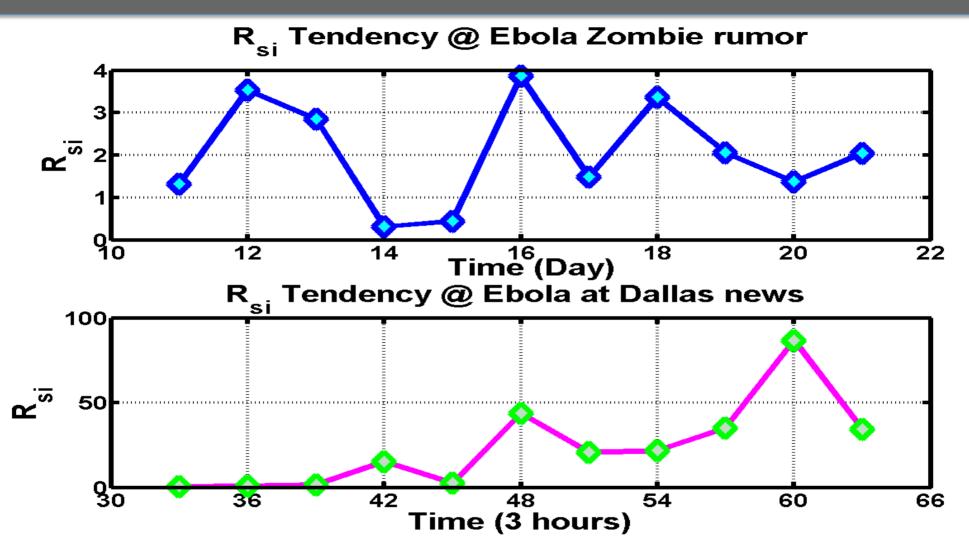
#### SEIZ results of Ebola rumors



# Reference

- Liang Zhao, Feng Chen, Jing Dai, Ting Hua, Chang-Tien Lu, and Naren Ramakrishnan. "Unsupervised Spatial Event Detection in Targeted Domains with Applications to Civil Unrest Modeling." PLOS ONE, vo. 9, no. 10 (2014): e110206.
- Fang Jin, Feng Chen, Rupinder Paul Khandpur, Chang-Tien Lu, Naren Ramakrishnan. *Absenteeism Detection in Social Media*, in Proceedings of the SIAM International Conference on Data Mining (SDM'17), Houston, TX, April 2017.
- 3. Fang Jin, Rupinder Paul Khandpur, Nathan Self, Edward Dougherty, Sheng Guo, Feng Chen, B. Aditya Prakash, Naren Ramakrishnan. *Modeling Mass Protest Adoption in Social Network Communities using Geometric Brownian Motion*, in Proceedings of the 20th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD'14), Aug 2014.
- 4. Fang Jin, Edward Dougherty, Parang Saraf, Peng Mi, Yang Cao, and Naren Ramakrishnan. *Epidemiological modeling of news and rumors on twitter*, in Proceedings of the 7th ACM SIGKDD Workshop on Social Network Mining and Analysis (SNA-KDD 2013), Chicago, IL, 2013, pages 8:1-8:9.
- Fang Jin, Wei Wang, Liang Zhao, Edward Dougherty, Yang Cao, Chang-Tien Lu, Naren Ramakrishnan. *Misinformation Propagation in the age of Twitter*, IEEE Computer, Volume 47, Issue 12, pages 90-94, Dec 2014.
- 6. Fang Jin, Nathan Self, Parang Saraf, Patrick Butler, Wei Wang, Naren Ramakrishnan. Forex-Foreteller: Currency Trend Modeling using News Articles, in Proceedings of the 19th ACM SIGKDD Conference on Knowledge Discovery and Data Mining - Demo Track, pages 1470--1473, Aug 2013.

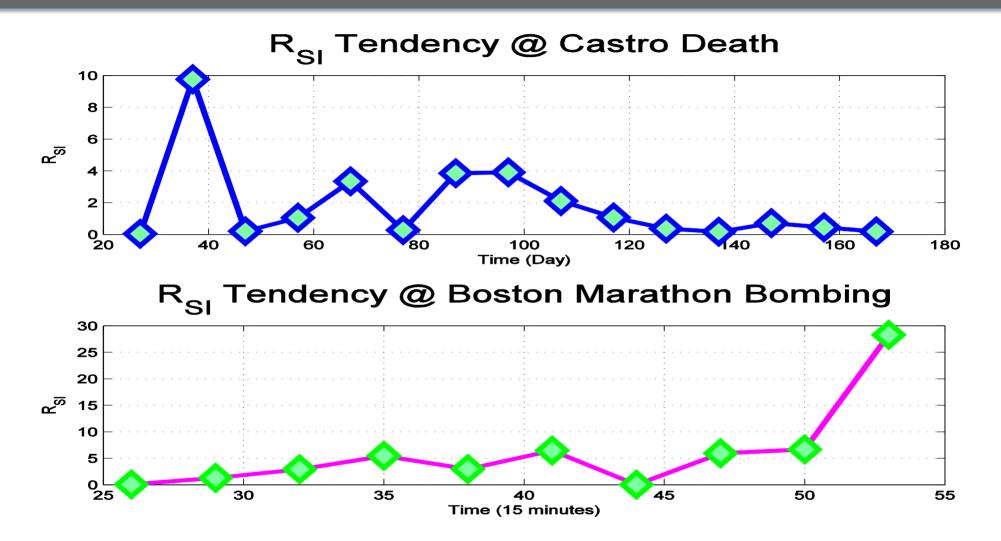
#### Response ratio time series



Response ratio is dynamically changing

> Need to train classifier to dynamically classify two classes.

### Response ratio time series



Response ratio is dynamically changing

> Need to train classifier to dynamically classify two classes.

# **Thank you** Fang Jin: <u>fang.jin@ttu.edu</u>