



空间大数据驱动的城市动态分析

Spatial big data driven urban dynamic analytics

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空间大数据 Spatial big data

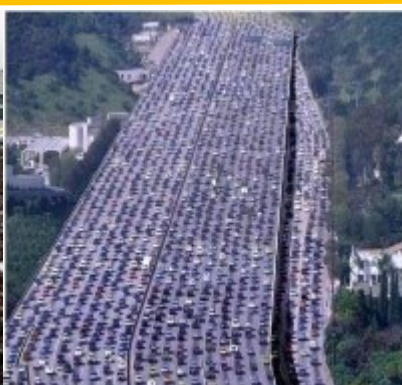
城市空间与人类活动相互影响

人 口



资源

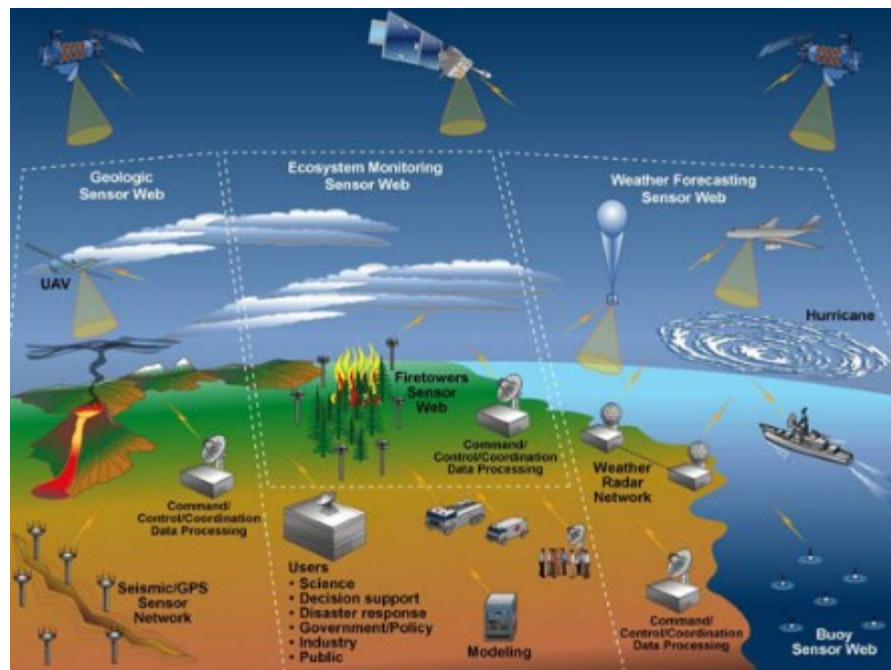
交通



社会

人类活动与资源、环境和经济发展等问题相互关联，紧密耦合

空间大数据支撑城市空间分析

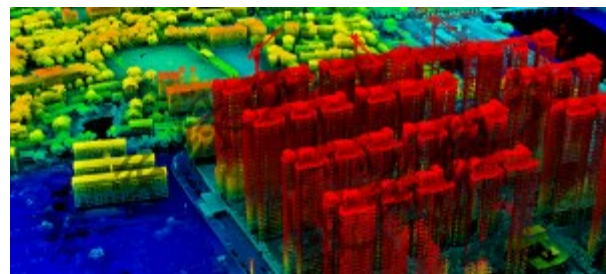


对地观测网络

“聚焦在空间”



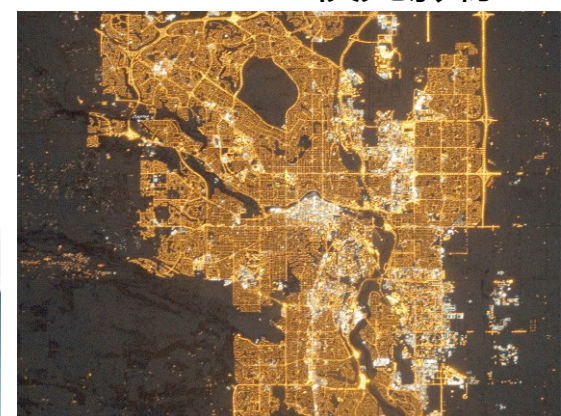
遥感影像



激光点云



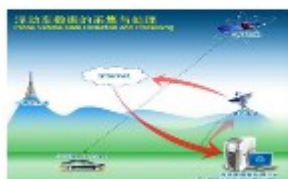
夜光影像



时空数据为城市动态分析带来了新机遇

与人相关的时空数据（如：手机定位数据、社交媒体数据、点评数据等）能够直接捕捉人类活动。

时空数据获取技术



GPS数据



手机数据



移动社交网络数据

...



时空大数据



选中	标识码	定位目标	数据名称	设备号	拍摄时间	分辨率	位置	高度角
<input checked="" type="checkbox"/>	001	001001001	001001001001	001001001001	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	002	002002002	002002002002	002002002002	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	003	003003003	003003003003	003003003003	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	004	004004004	004004004004	004004004004	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	005	005005005	005005005005	005005005005	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	006	006006006	006006006006	006006006006	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	007	007007007	007007007007	007007007007	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	008	008008008	008008008008	008008008008	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	009	009009009	009009009009	009009009009	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	010	010010010	010010010010	010010010010	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	011	011011011	011011011011	011011011011	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	012	012012012	012012012012	012012012012	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	013	013013013	013013013013	013013013013	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	014	014014014	014014014014	014014014014	2010-10-10 10:10:10	10	10.1010101010	10.10
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<input checked="" type="checkbox"/>	016	016016016	016016016016	016016016016	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	017	017017017	017017017017	017017017017	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	018	018018018	018018018018	018018018018	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	019	019019019	019019019019	019019019019	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	020	020020020	020020020020	020020020020	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	021	021021021	021021021021	021021021021	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	022	022022022	022022022022	022022022022	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	023	023023023	023023023023	023023023023	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	024	024024024	024024024024	024024024024	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	025	025025025	025025025025	025025025025	2010-10-10 10:10:10	10	10.1010101010	10.10
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<input checked="" type="checkbox"/>	027	027027027	027027027027	027027027027	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	028	028028028	028028028028	028028028028	2010-10-10 10:10:10	10	10.1010101010	10.10
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<input checked="" type="checkbox"/>	031	031031031	031031031031	031031031031	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	032	032032032	032032032032	032032032032	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	033	033033033	033033033033	033033033033	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	034	034034034	034034034034	034034034034	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	035	035035035	035035035035	035035035035	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	036	036036036	036036036036	036036036036	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	037	037037037	037037037037	037037037037	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	038	038038038	038038038038	038038038038	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	039	039039039	039039039039	039039039039	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	040	040040040	040040040040	040040040040	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	041	041041041	041041041041	041041041041	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	042	042042042	042042042042	042042042042	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	043	043043043	043043043043	043043043043	2010-10-10 10:10:10	10	10.1010101010	10.10
<input checked="" type="checkbox"/>	044	044044044	044044044044	044044044044	2010-10-10 10:10:10	10	10.1010101010	10.10
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<input checked="" type="checkbox"/>	082	082082082	082082082082	082082082082	2010-10-10 10:10:10	10	10.1010101010	10.10
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<input checked="" type="checkbox"/>	087	087087087	087087087087	087087087087	2010-10-10 10:10:10	10	10.1010101010	10.10
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2

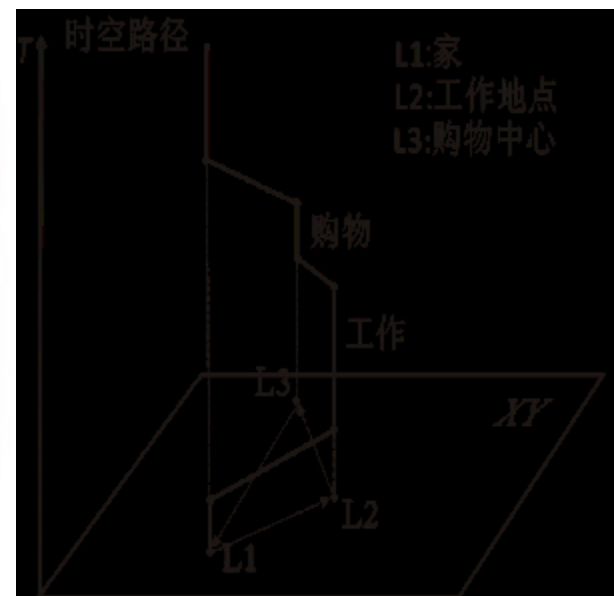
人类活动动态 Human activity dynamic

人类活动收集



问卷调查

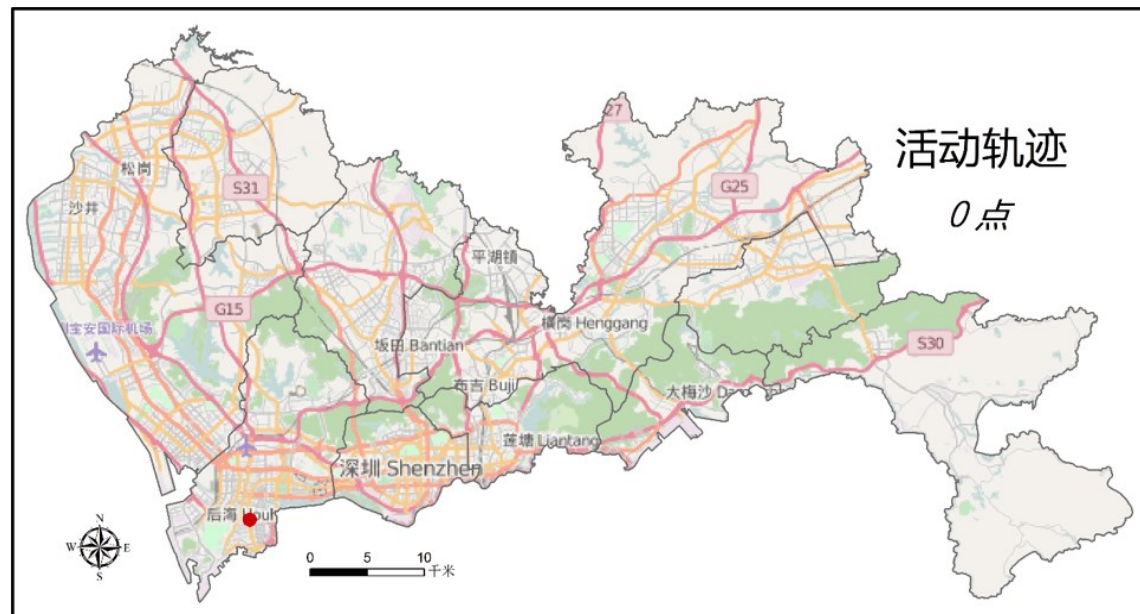
渗透率低（1%-5%），费时费力



GPS调查

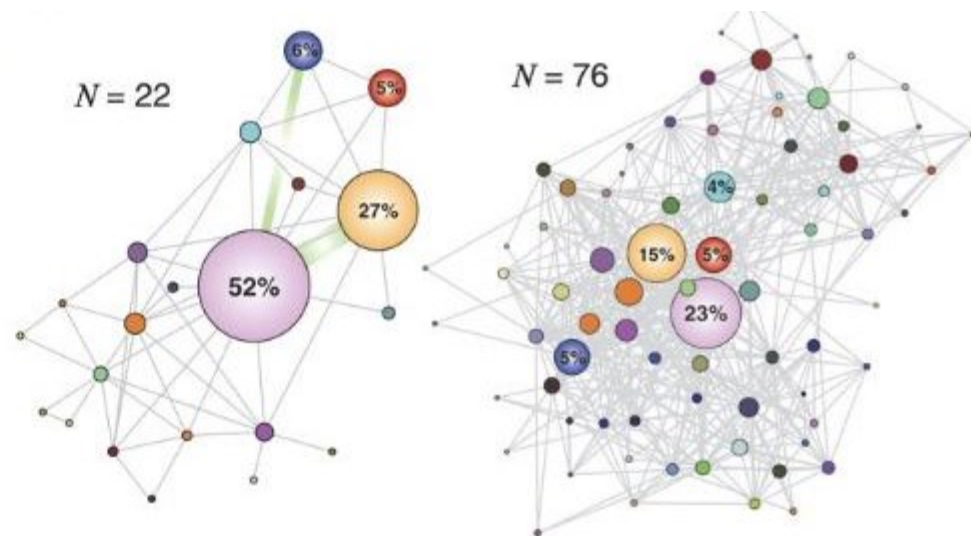
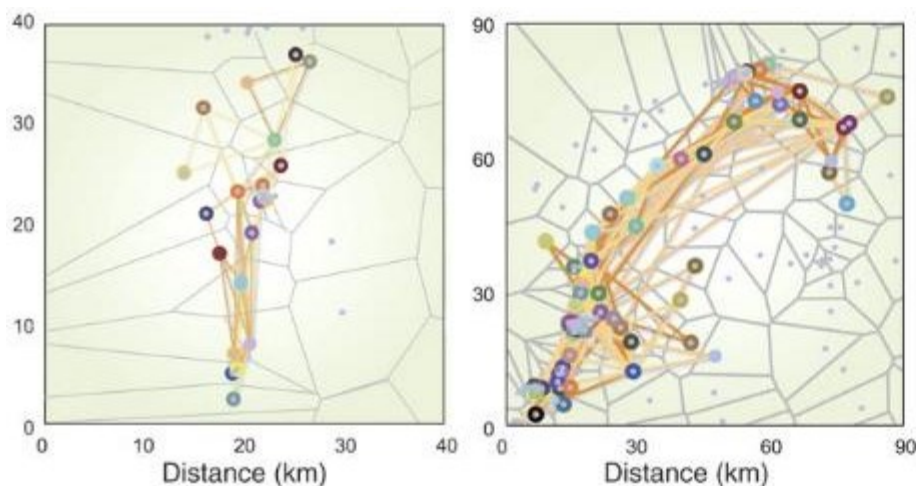
精准，但是找志愿者很难

“我的一天”



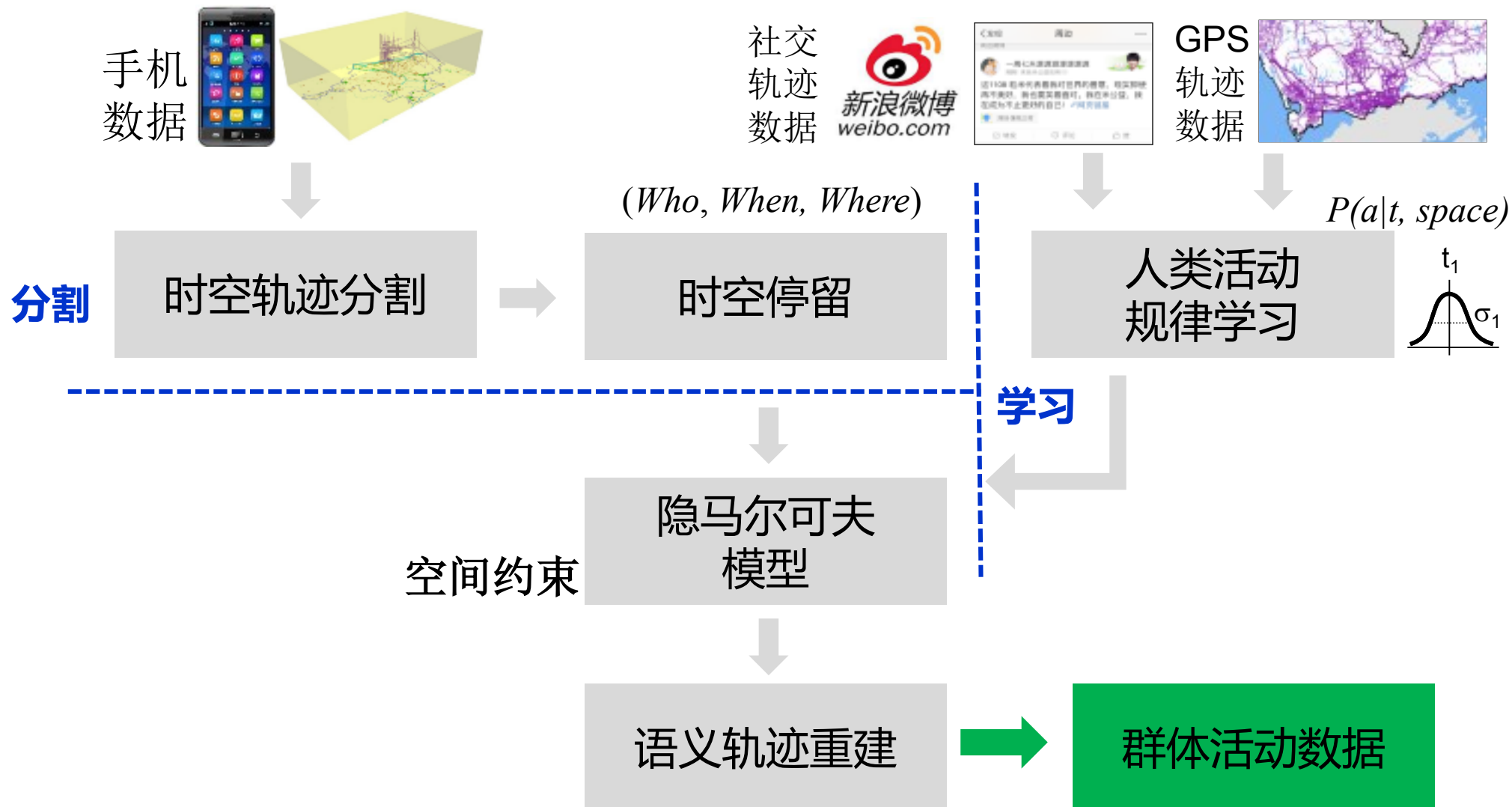
人类移动具有规律性

从时空数据中恢复群体活动是否可行？

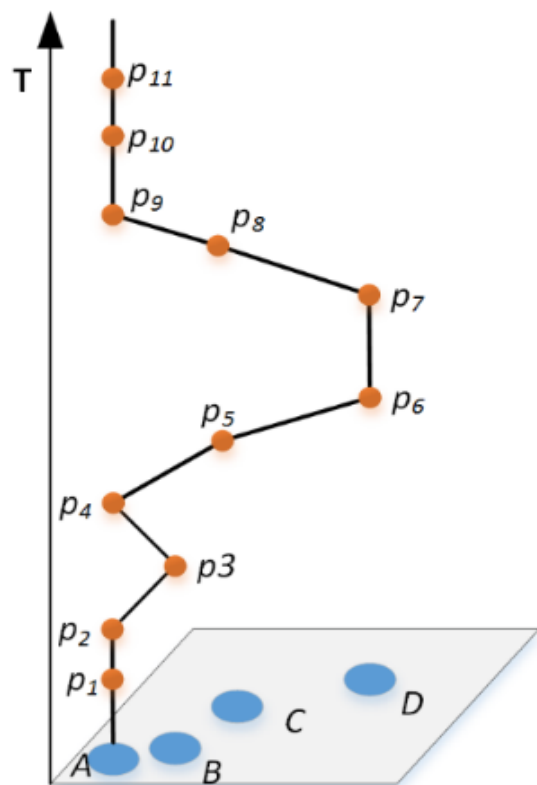


手机数据实证： 个体到访的地点是有限的，高频到访地点非常显著(song et al., 2008)。

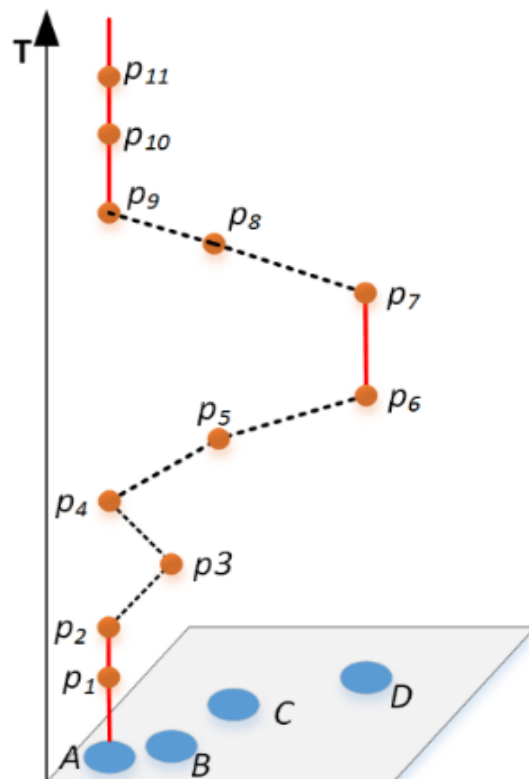
人类活动的时空语义标记



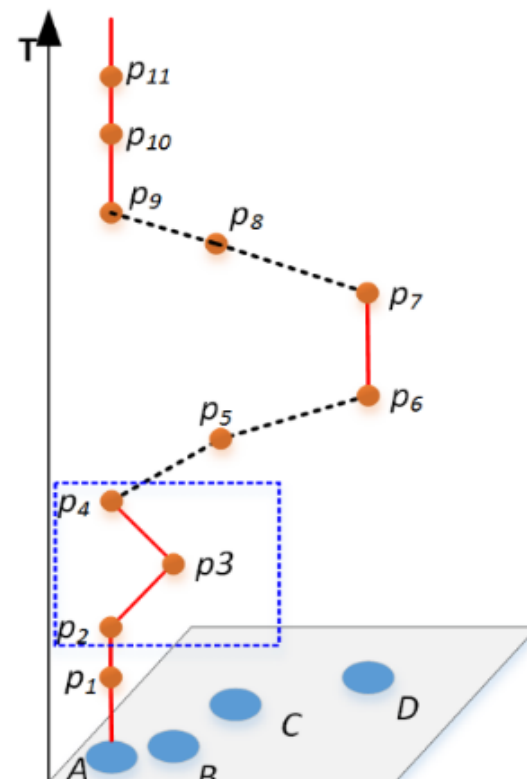
时空轨迹分割



(a) trajectory



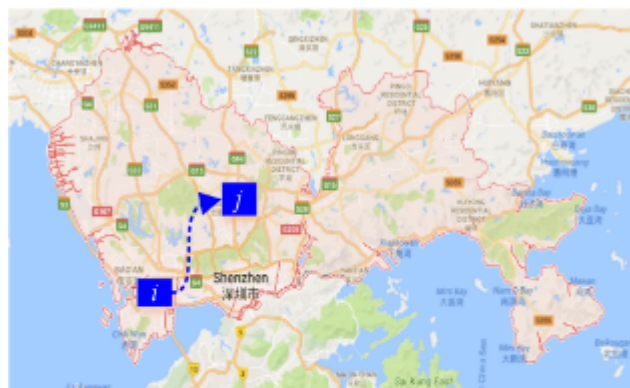
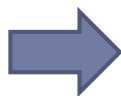
(b) segmentation



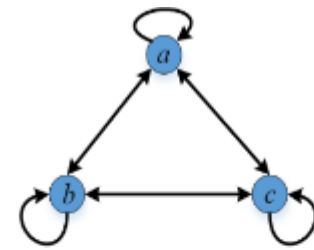
(c) near point merging

- **91.9%** 手机用户成功标记家
- **64.8%** 手机用户成功标记工作地
- **75.7%** 潜在活动已经成功标记

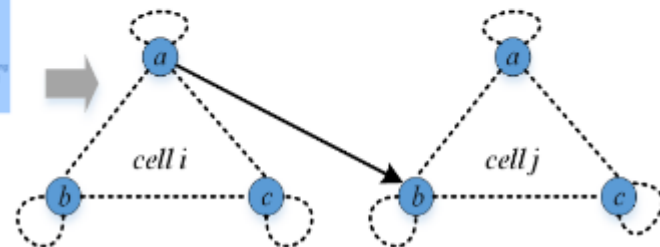
基于新浪微博签到数据的社会活动知识学习



● activity



(a) activity transition



(b) activity transition between urban cells

活动分布概率:

$$p(a|i) = \frac{N_a^i}{\sum_{a \in A} N_a^i}$$

a, b : 活动

活动转移概率:

$$p(ab|ij) = \frac{N_{ab}^{ij}}{\sum_{a \in A, b \in A} N_{ab}^{ij}}$$

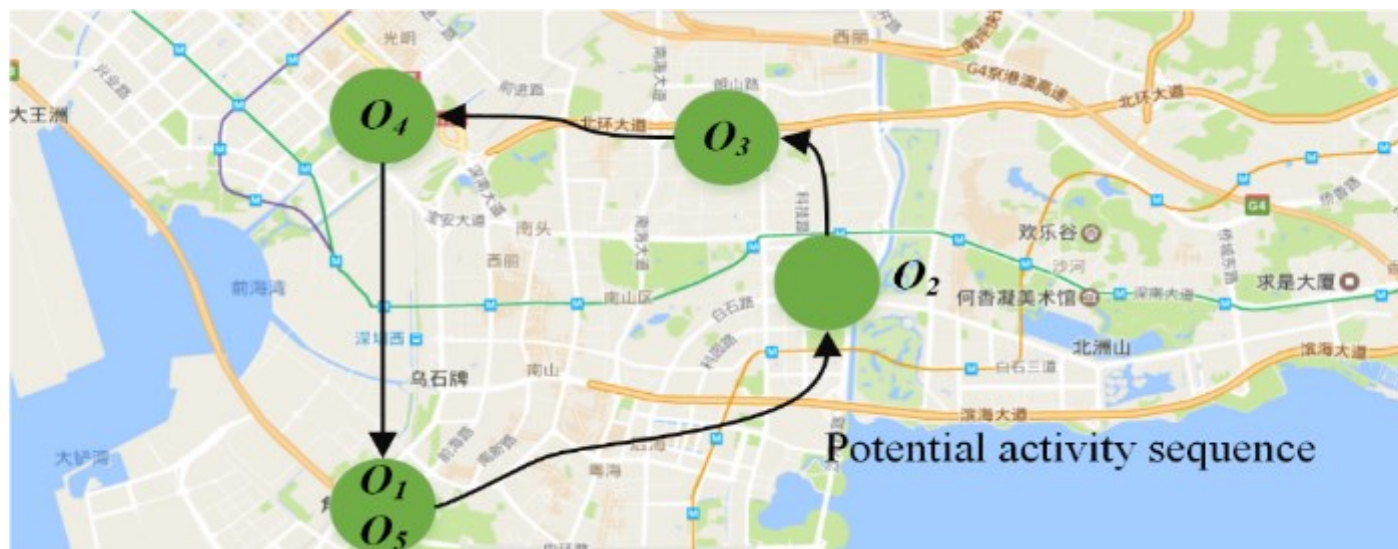
i, j : 地点

时变活动转移概率:

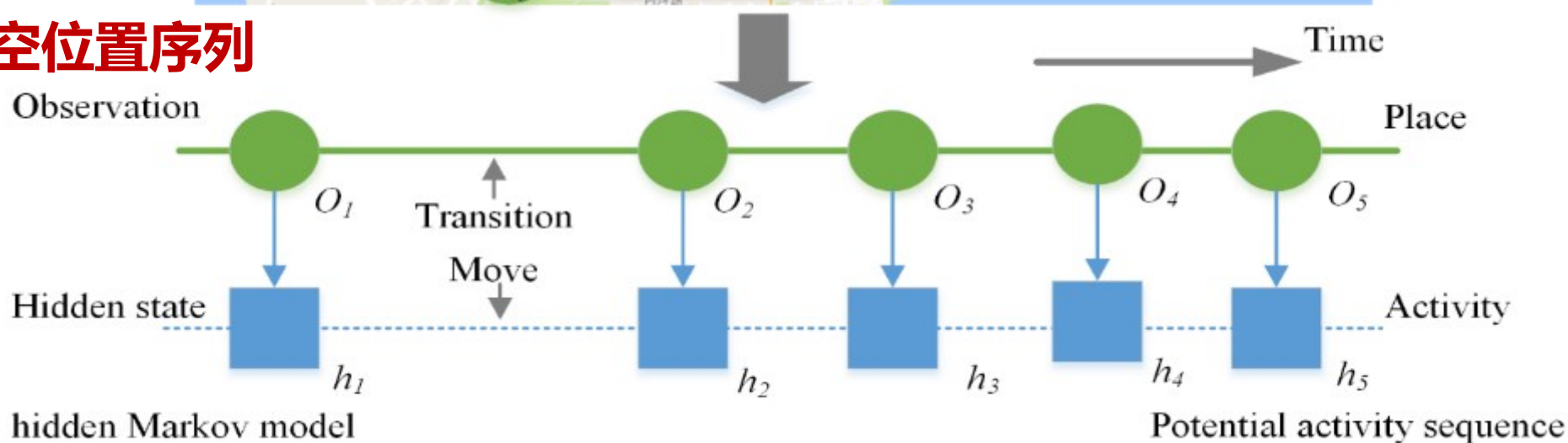
$$p(ab|ijpq) = \frac{N_{ab}^{ijpq}}{\sum_{a \in A, b \in A} N_{ab}^{ijpq}}$$

p, q : 时间

基于隐含马尔可夫模型的社会化活动标记



时空位置序列

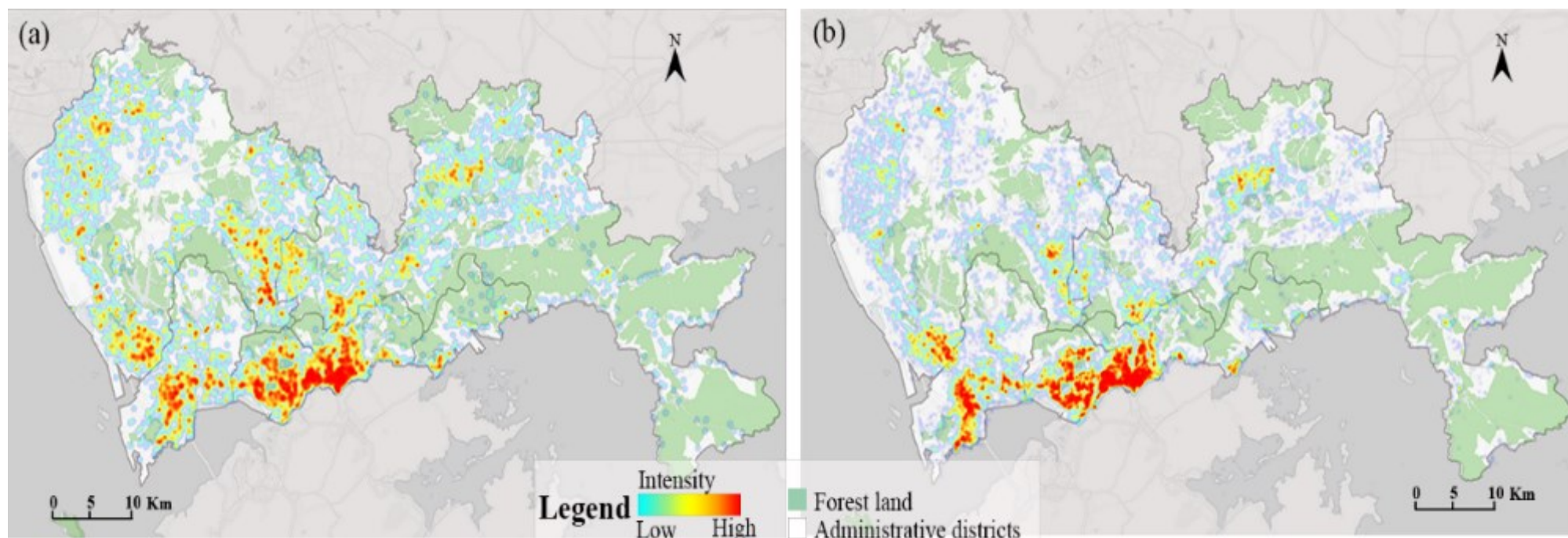


个体活动序列

大规模手机数据实验验证

手机定位数据：920 万用户（深圳全市人口约1800万，2012）

社交媒体数据：52万用户，2013年全年的数据



手机数据分布

社交媒体数据分布

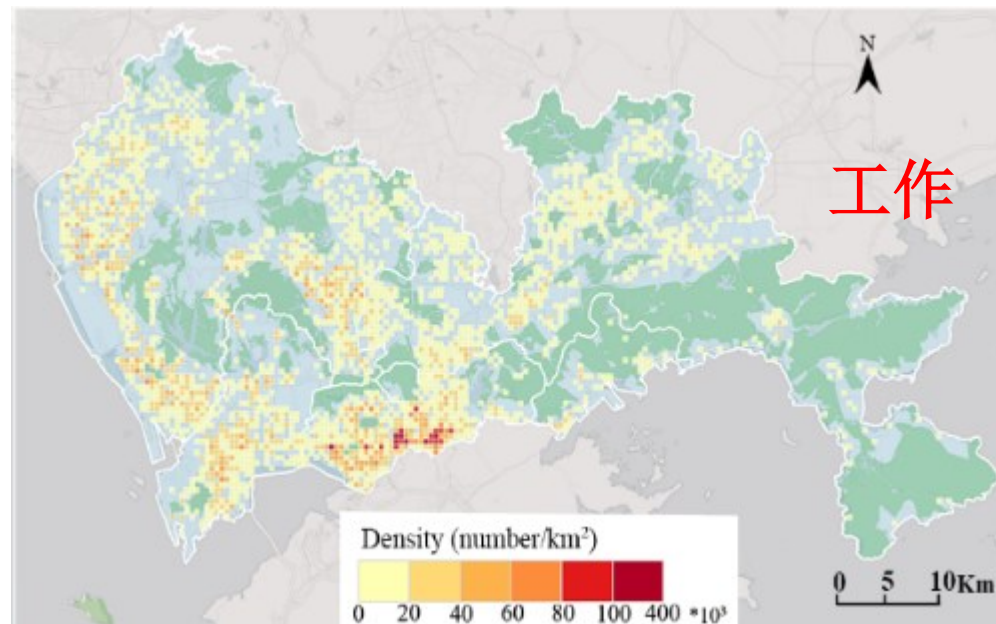
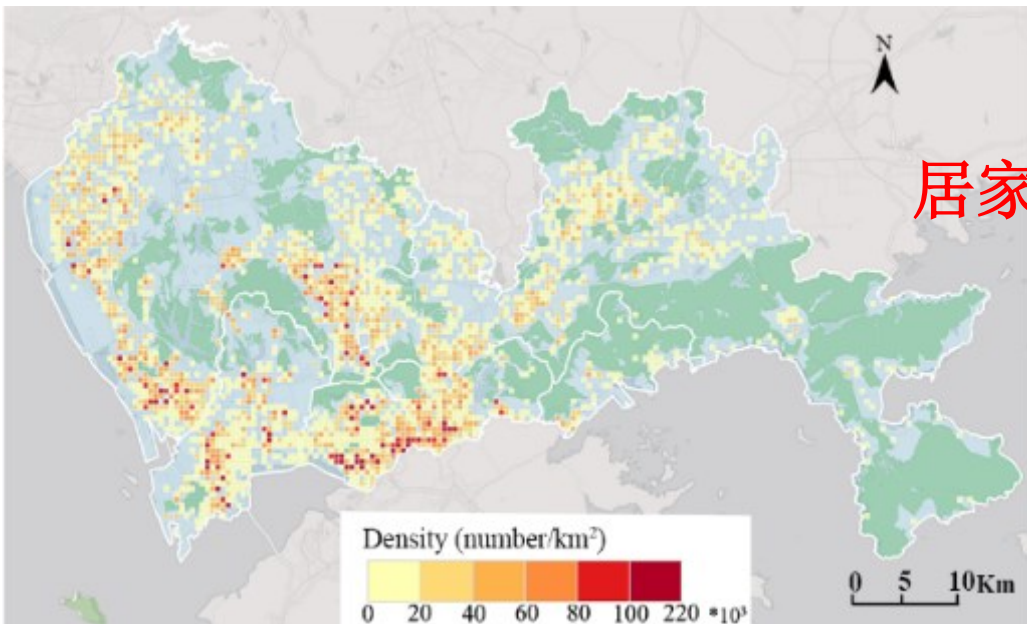
群体活动总体情况

920万用户 总共活动 31669042 个，人均 **3.43** 个/天

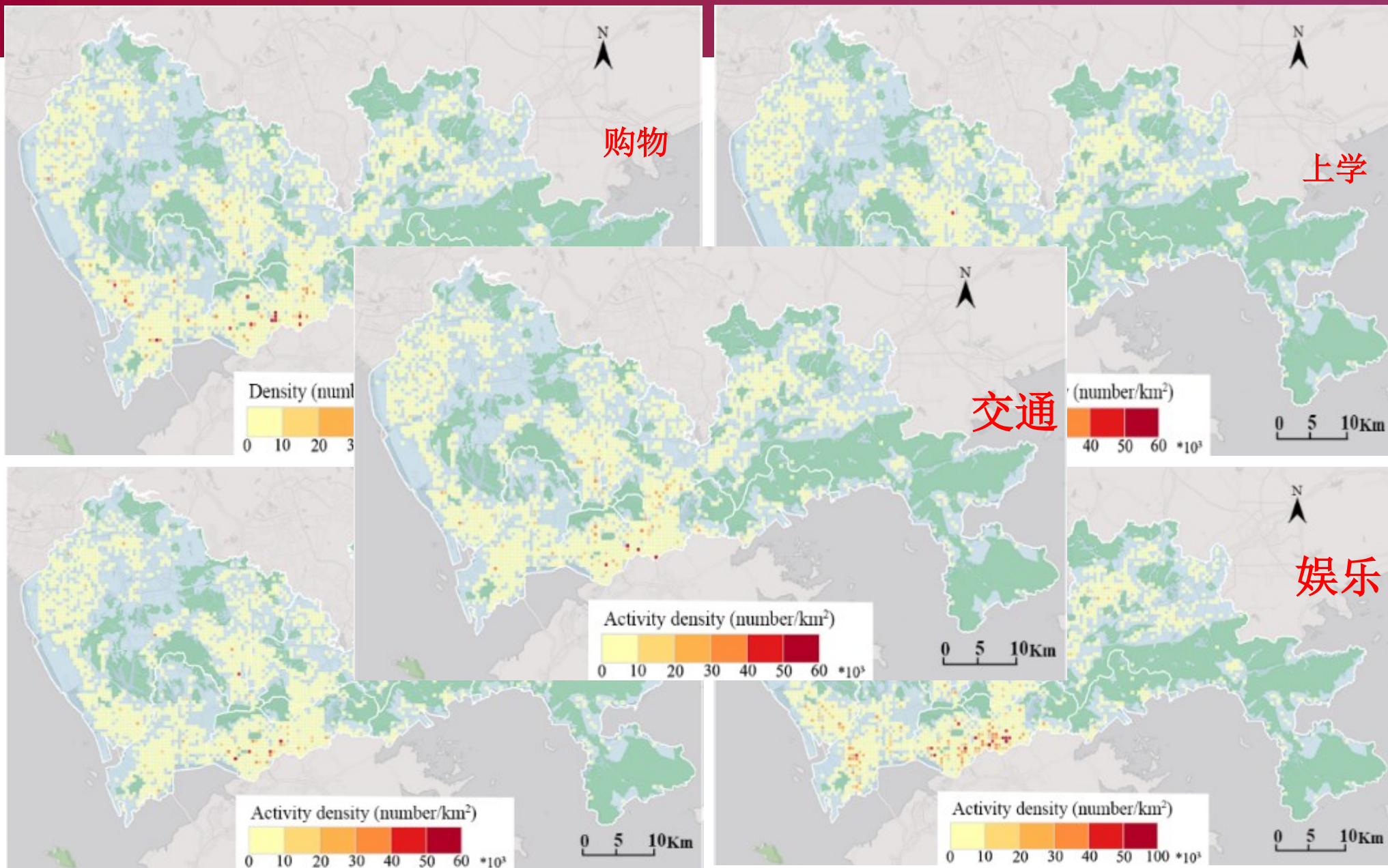
活动	居家	工作	社会化活动				
			交通	上学	购物	休闲	娱乐
数量	14 470 460	10 459 657	1 228 703	872 231	1 428 106	801 288	2 408 597
比例	45.7%	33.0%	3.9%	2.8%	4.5%	2.5%	7.6%
深圳市2010 交通调查中的 活动比例	42.85%	34.32%	2.96%	4.79%	4.13%	2.52%	-

* TAZ尺度上，居家活动和常住人口的相关系数为**0.92**

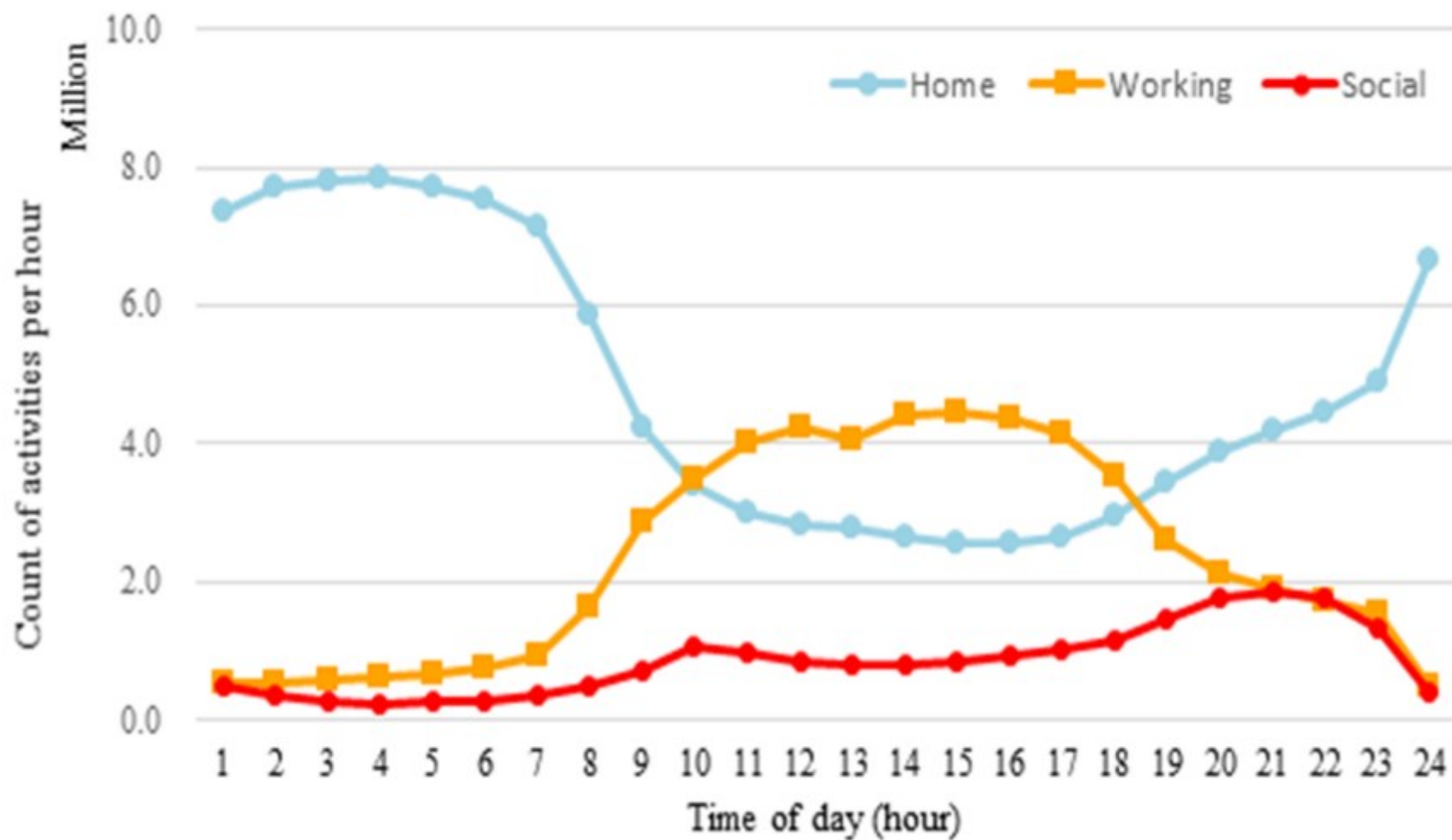
居家活动 VS 工作活动



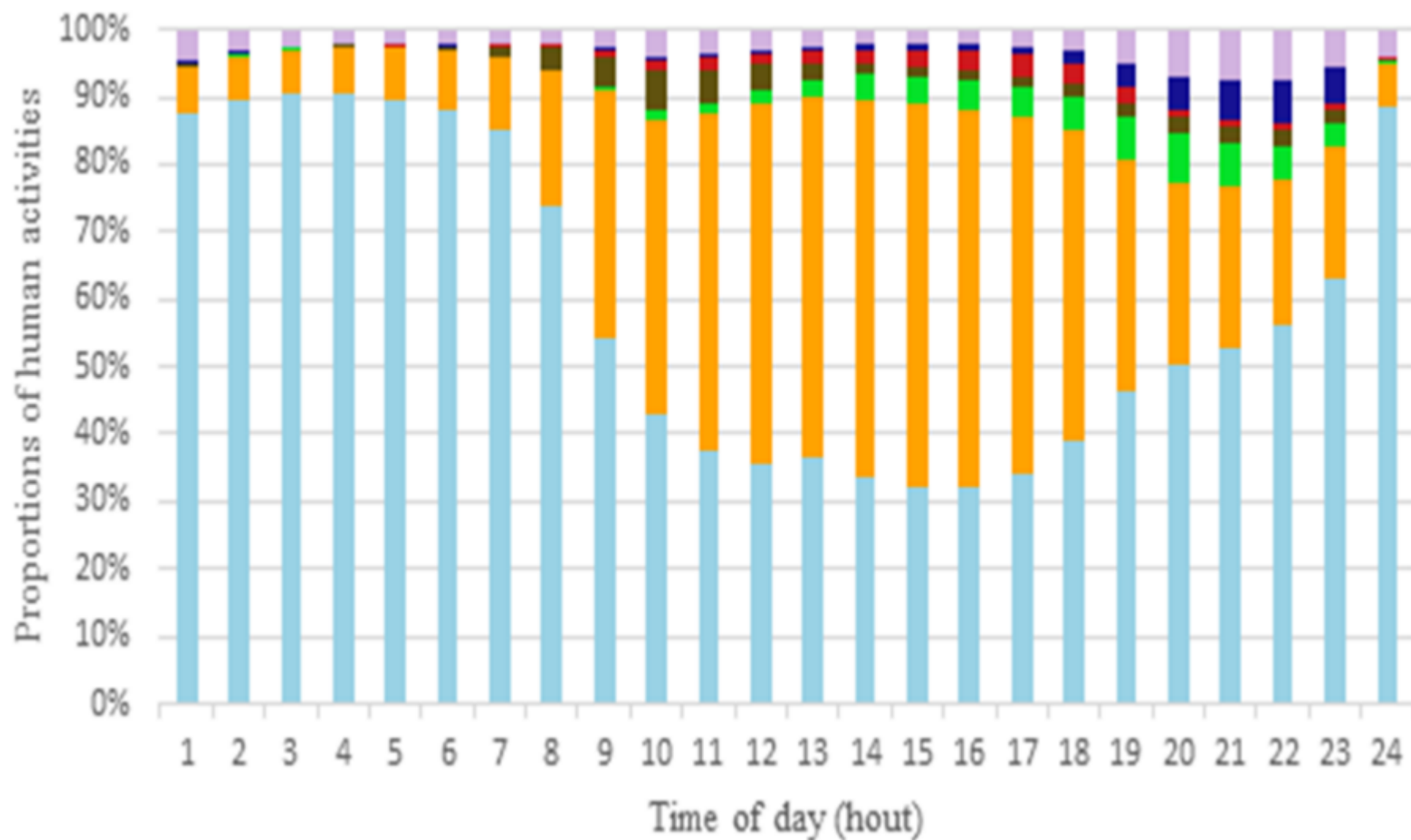
社会化活动



时间维度：群体活动时变动态



时间维度：群体活动时变动态





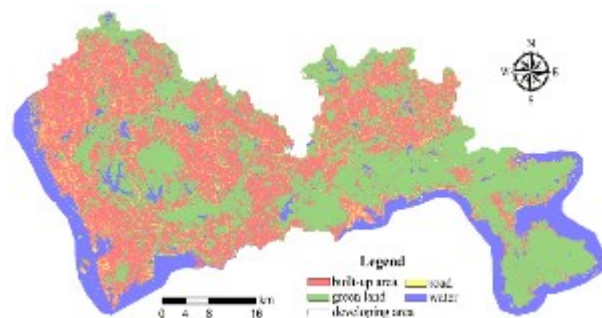
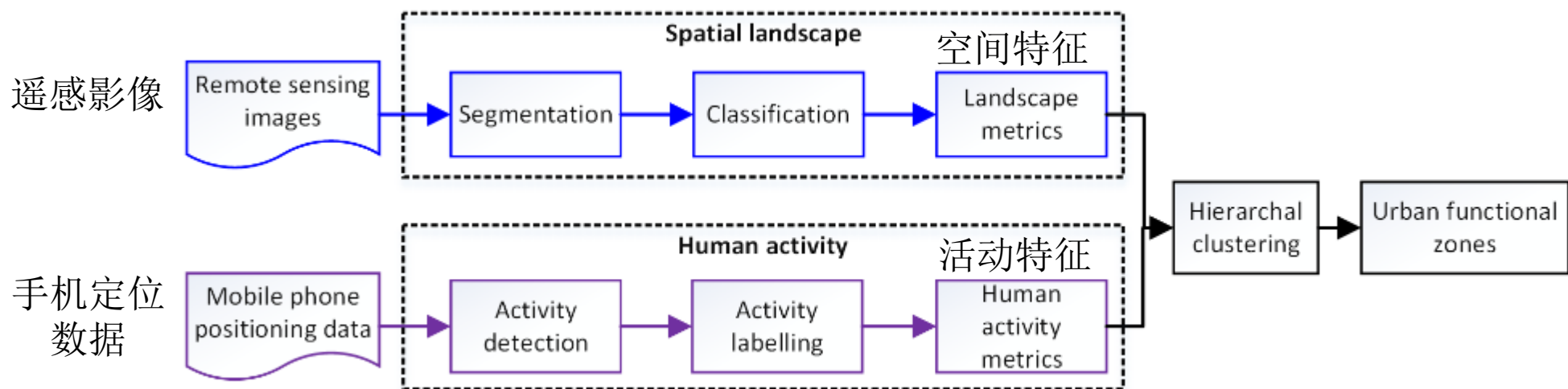
3

城市功能动态

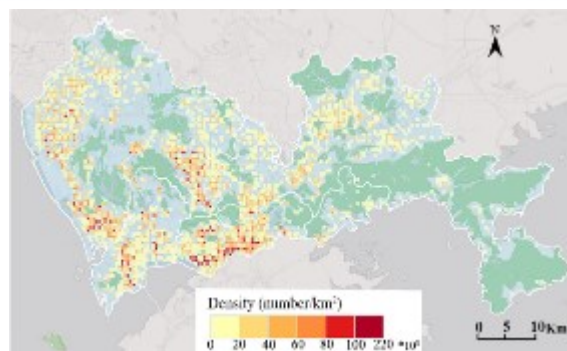
Urban functional dynamic

城市功能的空间动态

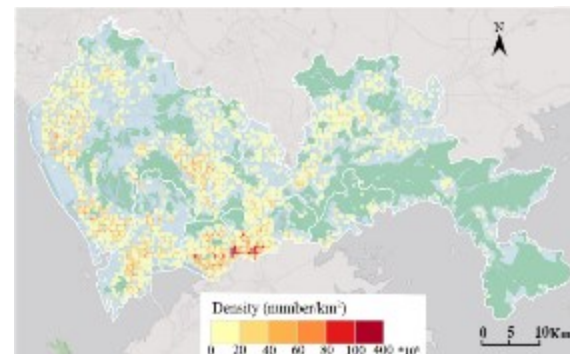
■ 融合遥感影像和人类活动分析城市功能空间动态



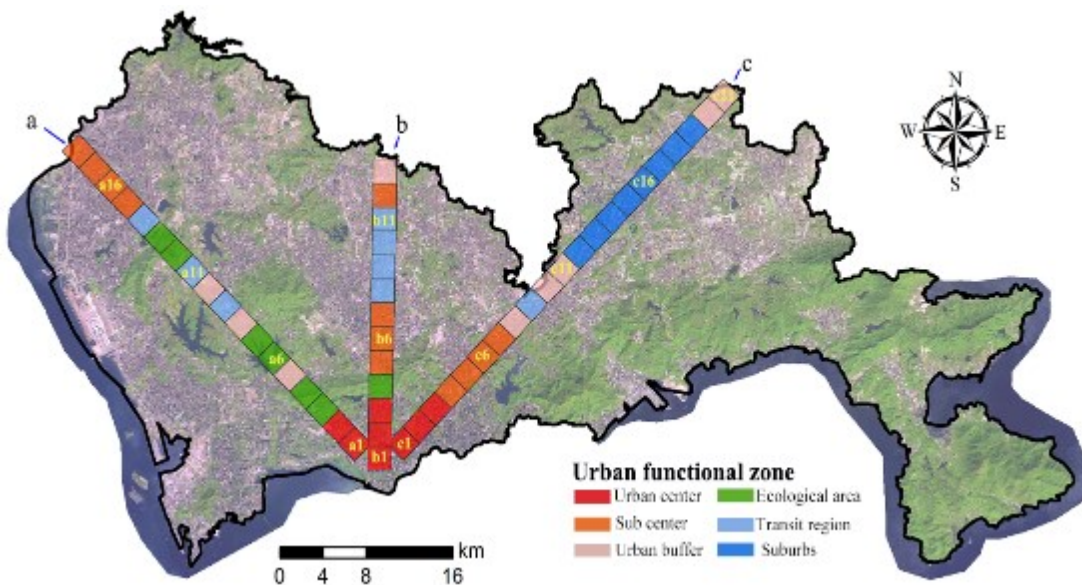
遥感数据：土地覆盖



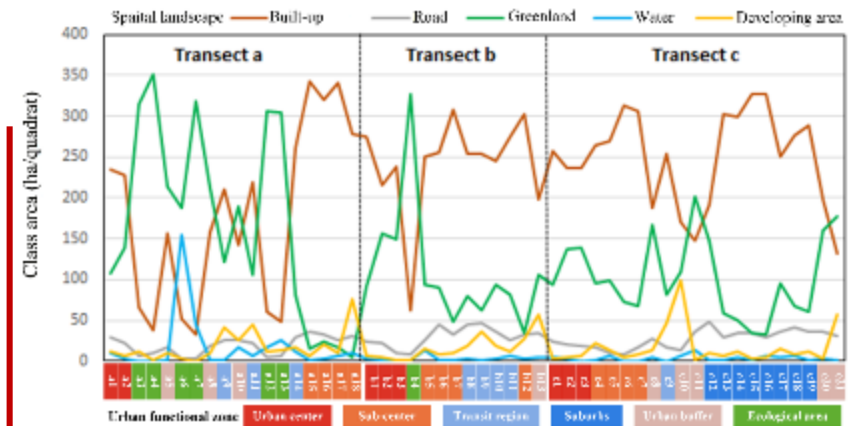
手机数据：人类活动（居家、工作、社会活动）



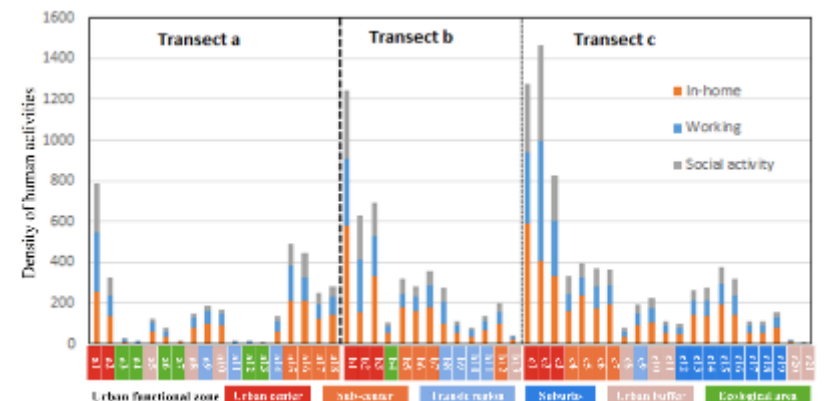
城市功能的空间动态



城市功能空间梯度



土地覆盖梯度



人类活动梯度

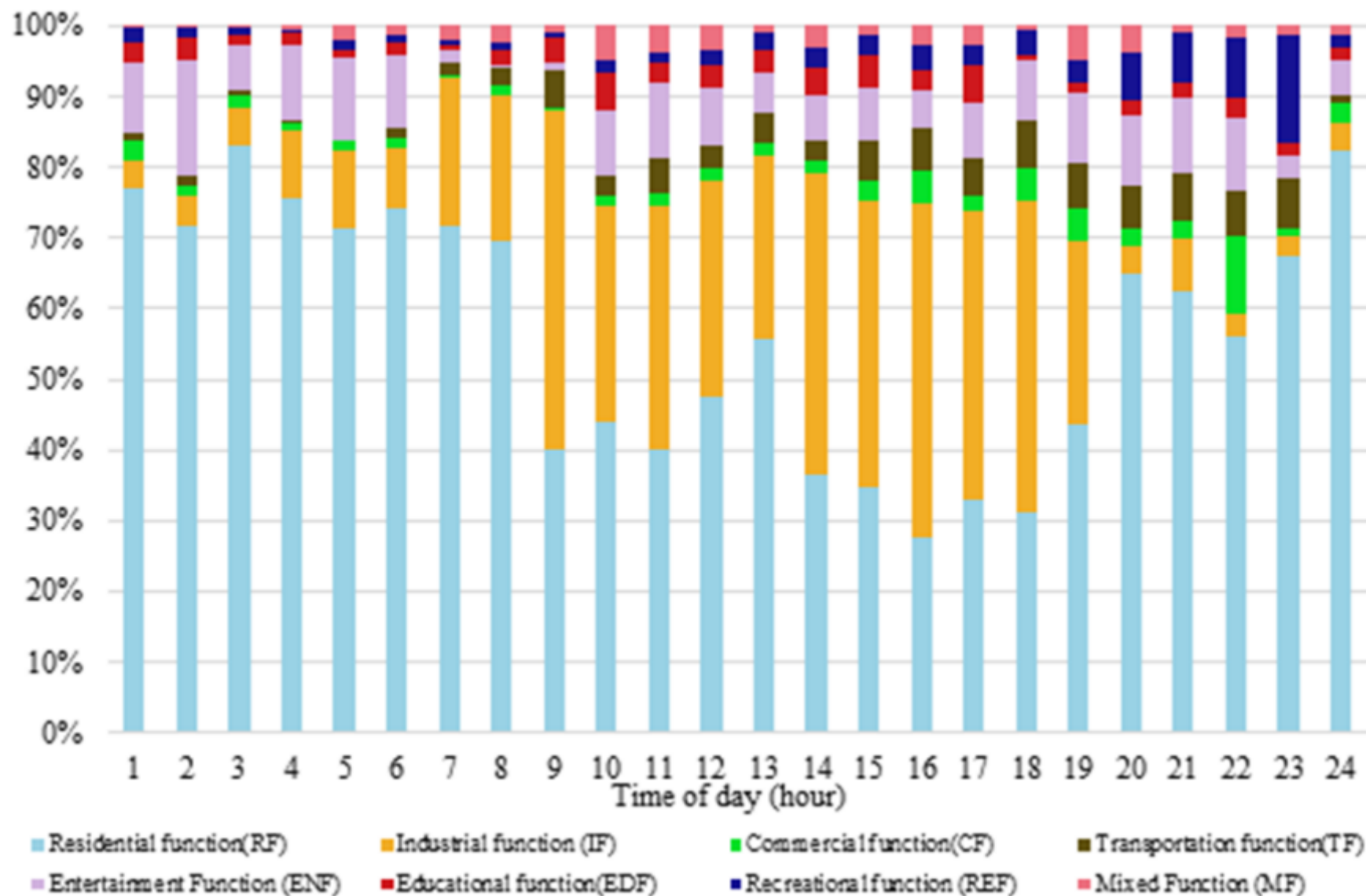
TU Wei, et al. Portraying Urban Functional Landscape Gradient by Coupling Remote Sensing Imagery and Human Sensing data. Remote sensing. 2017. (Under review).

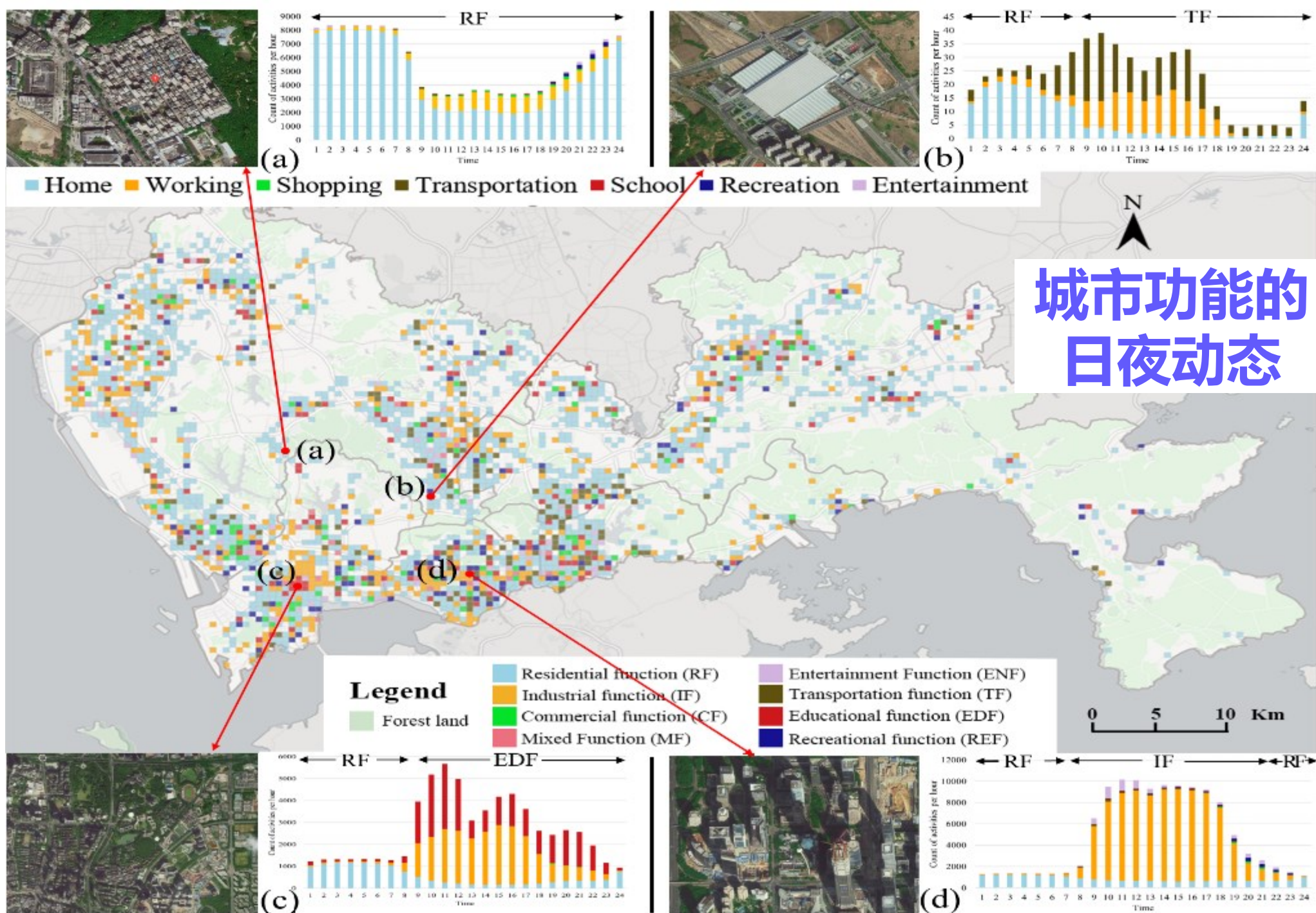
城市功能的时间动态

基于人类活动进行非监督聚类，标记地块功能

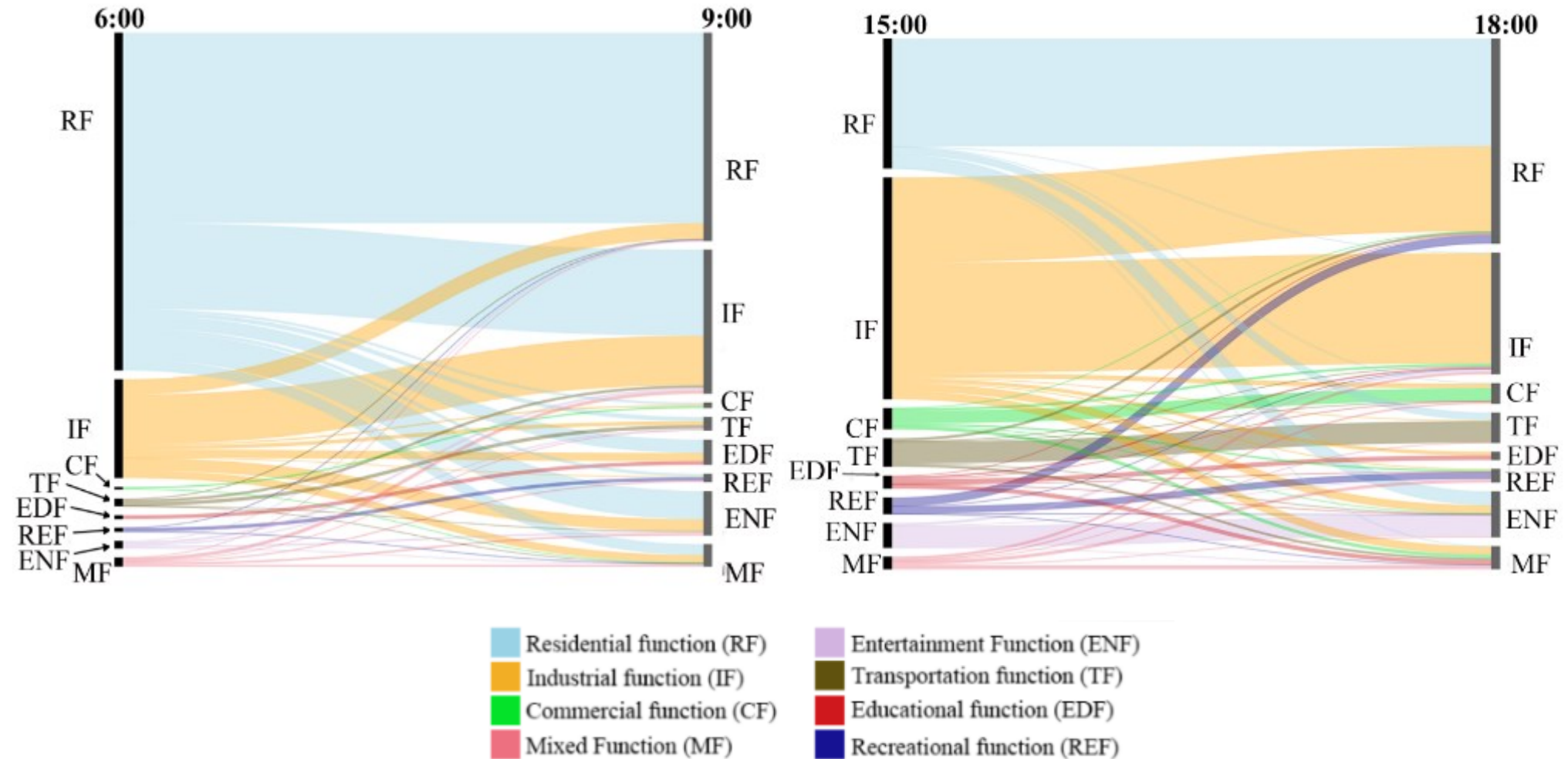


城市功能的日夜动态





城市功能的日夜动态



TU Wei, CAO Jinzhou, YUE Yang, et al. Coupling mobile phone and social media data: a new approach to understanding urban functions and diurnal patterns. International Journal of Geographical Information Science. 2017, 31(12), 2331-2358.



4

总结与展望 Conclusion and Outlook

4. 总结与展望

- 空间大数据，特别是时空数据中蕴含了丰富的人类活动信息，能够支撑精细化人类活动动态感知
- 高渗透精细化人类群体活动能够实现高动态城市功能分析
- GIS为链接城市空间、人、数据和智能提供了可能

敬请批评指正！
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