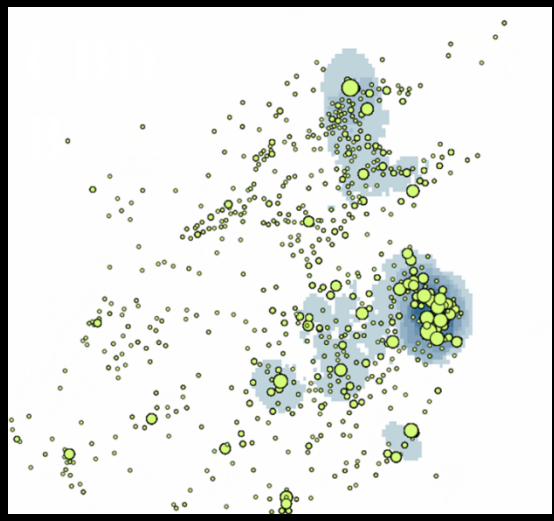
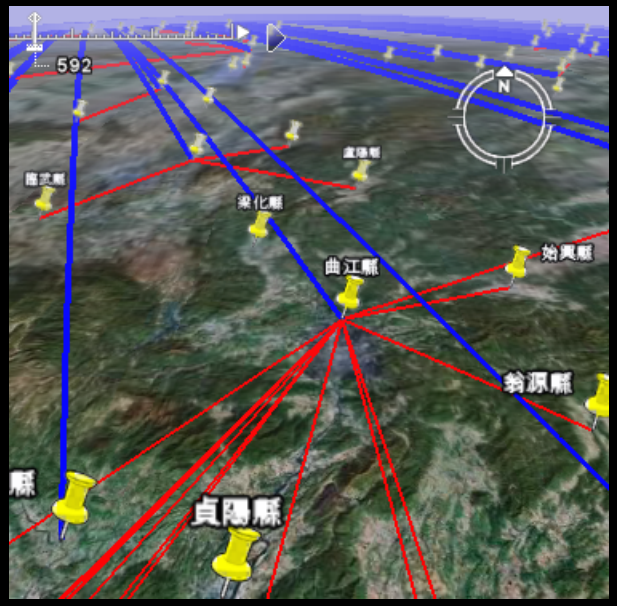
Gov 1003
4 Mar 2013

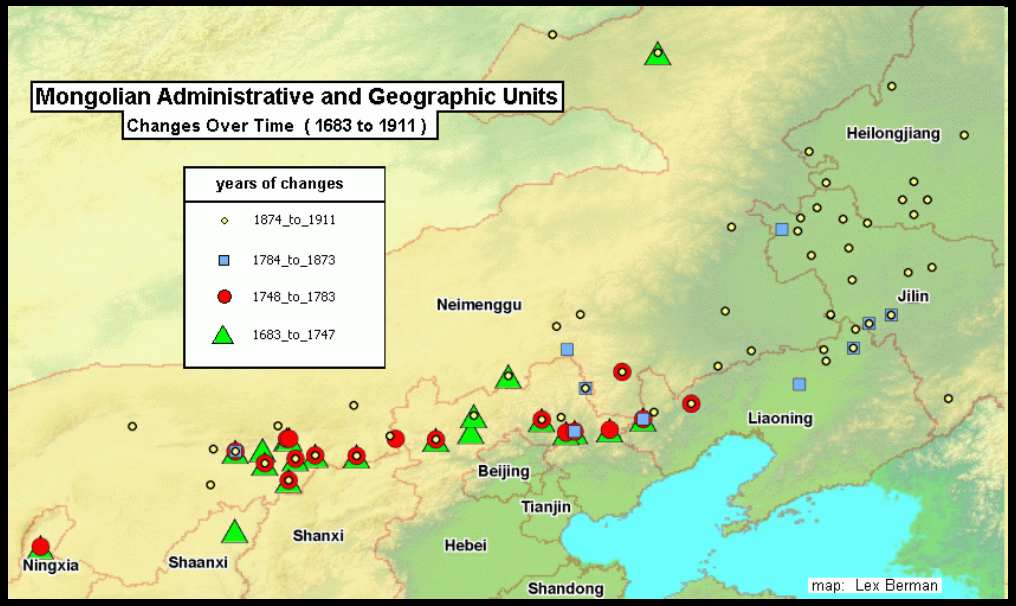
merrick lex berman
center for geographic analysis

from data to analysis and visualization

NAME_PY	NAME_CH	NAME_FT	PRES_LOC	BEG_YR	END_YR
Yancheng Xian	盐城县	鹽城縣	江苏盐城市治	1911	1911
Funing Xian	阜宁县	阜寧縣	江苏阜宁县治	1911	1911
Shanyang Xian	山阳县	山陽縣	江苏淮安市治	1911	1911
Qinghe Xian	清河县	清河縣	江苏淮阴市治	1911	1911
Taoyuan Xian	桃源县	桃源縣	江苏泗阳县城厢	1911	1911
Andong Xian	安东县	安東縣	江苏涟水县治	1911	1911
Ganyu Xian	赣榆县	贛榆縣	江苏赣榆县赣...	1911	1911
Shuyang Xian	沭阳县	沭陽縣	江苏沭阳县治	1911	1911
Feng Xian	丰县	豐縣	江苏丰县治	1911	1911
Pei Xian	沛县	沛縣	江苏沛县治	1911	1911
Dangshan Xian	砀山县	碭山縣	安徽砀山县治	1911	1911







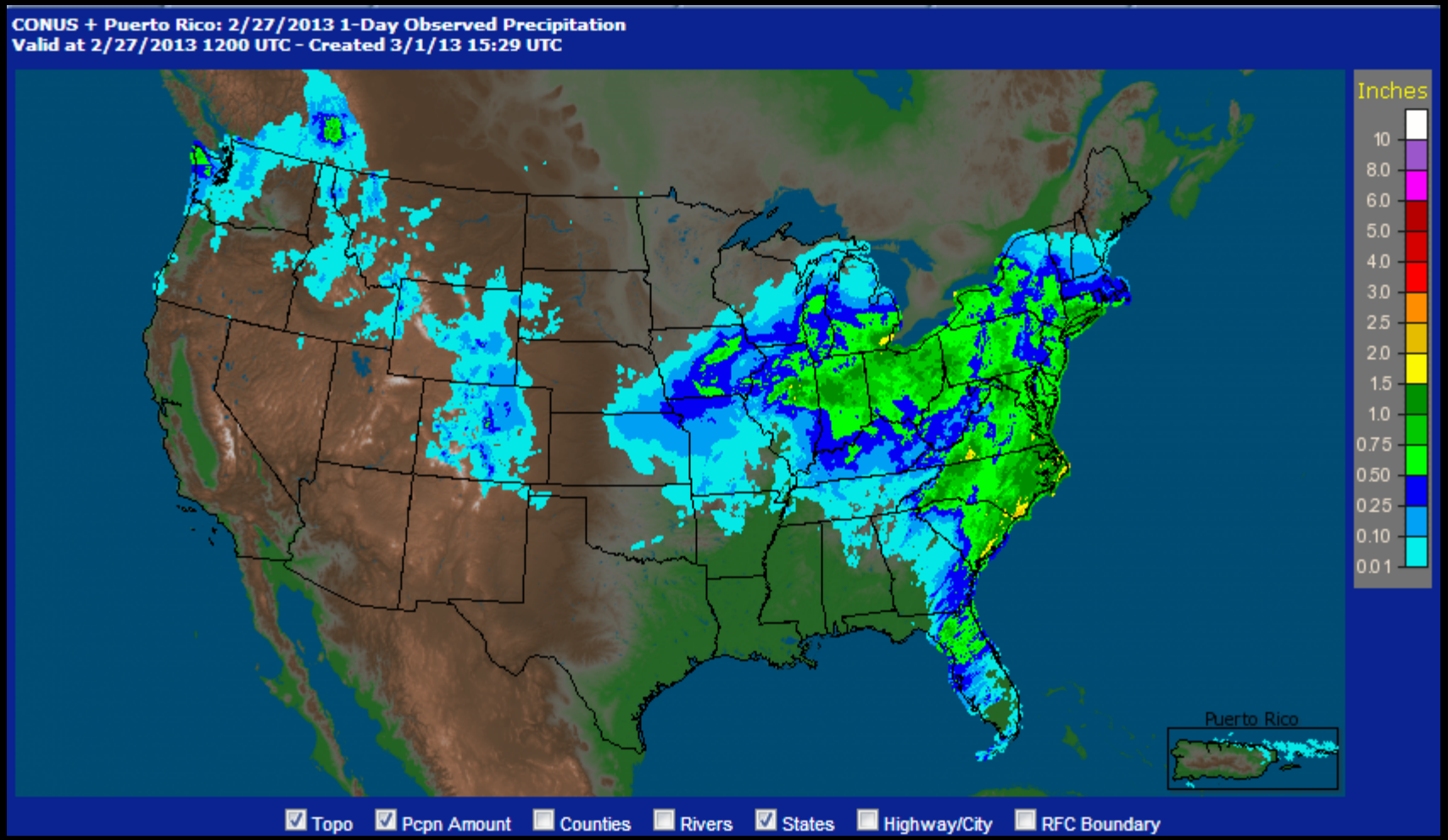
How to record time values

- intervals
- timestamps
- begin – end dates

How to visualize GIS objects with time values

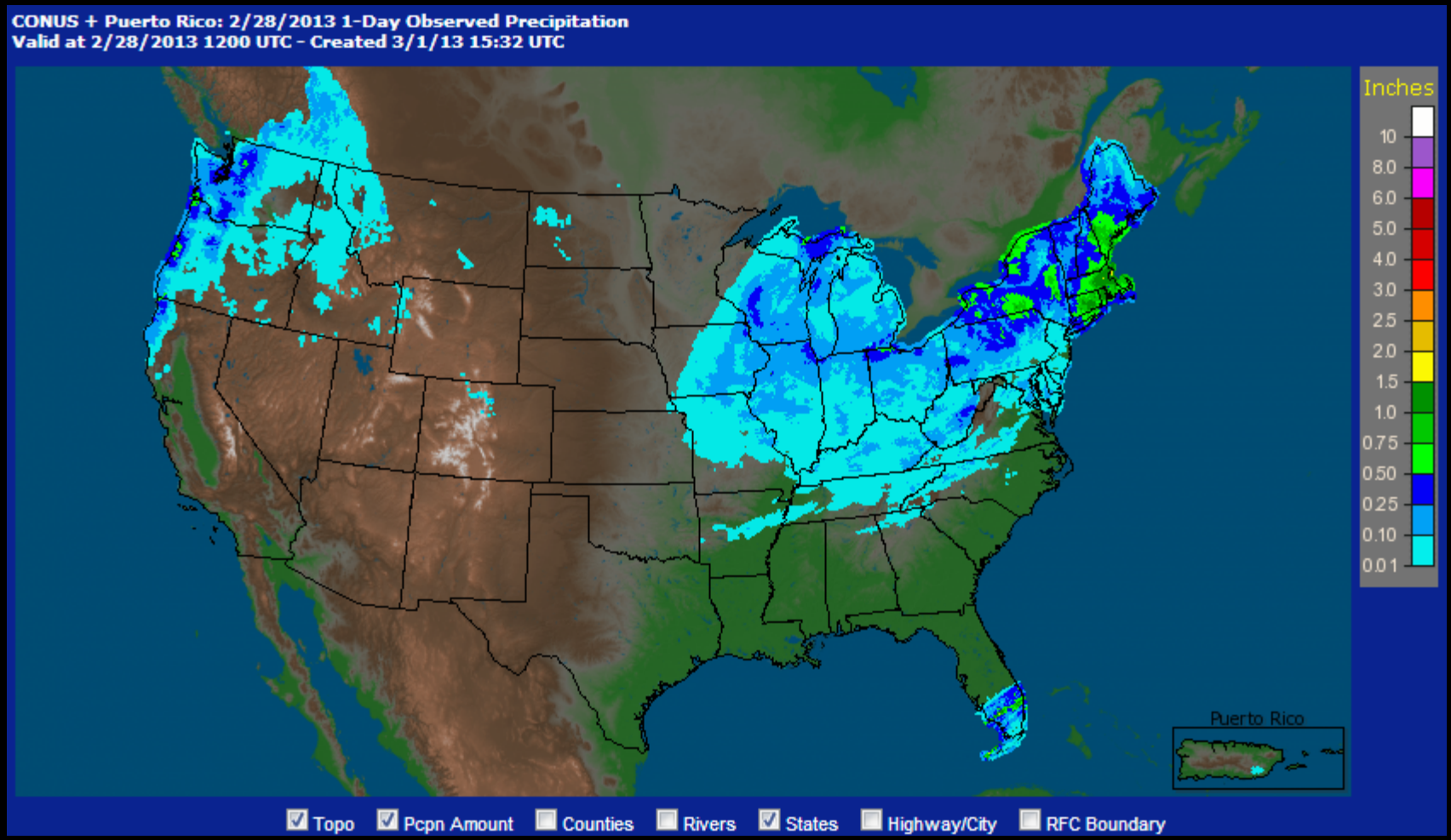
- z-axis
- animations
- maps + timelines

Intervals - sensor data



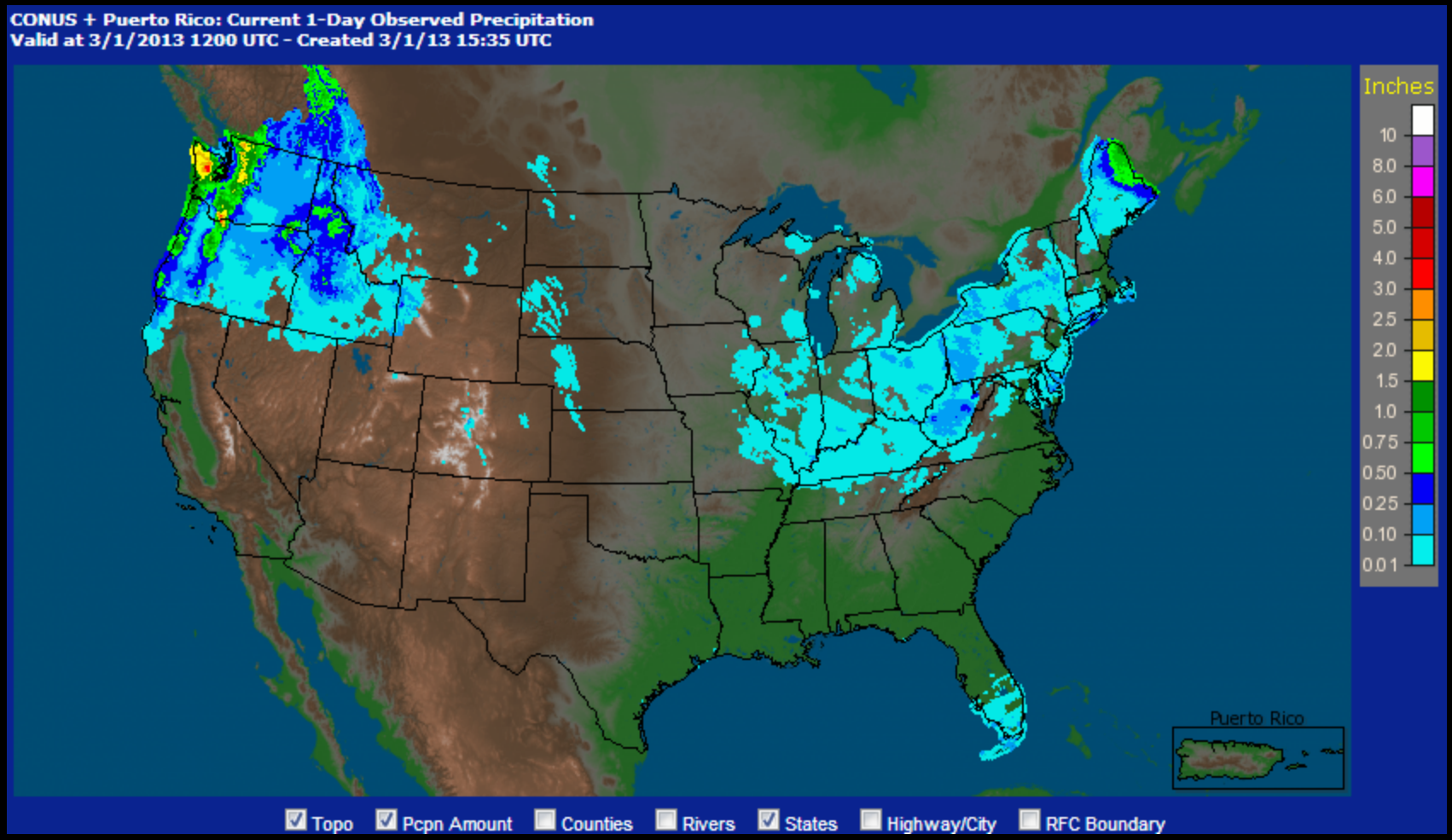
Source: AHPS http://water.weather.gov/precip/

Intervals - sensor data



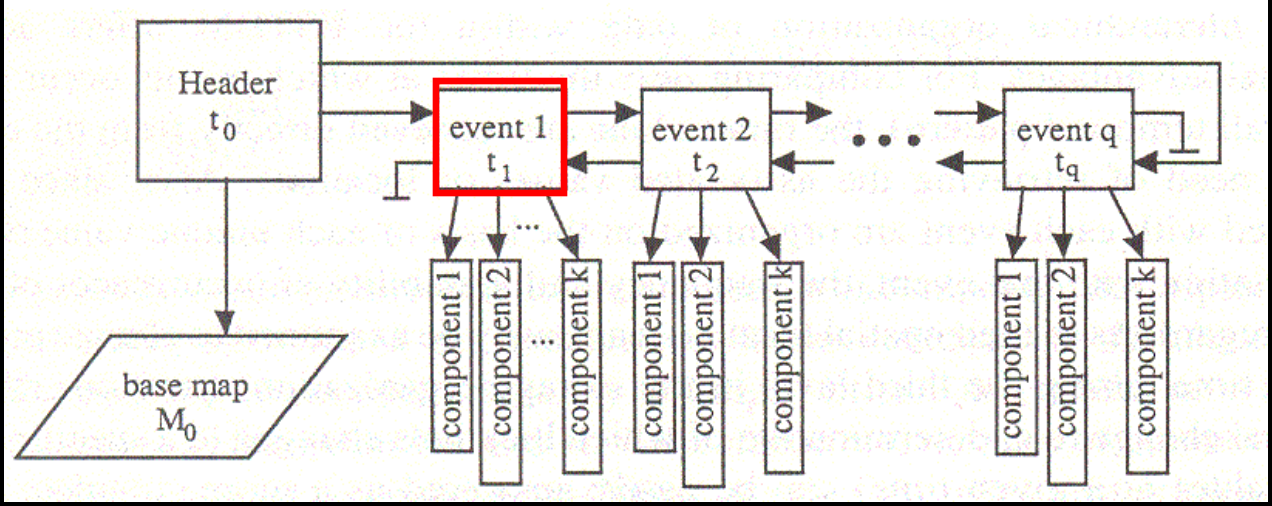
Source: AHPS http://water.weather.gov/precip/

Intervals - sensor data

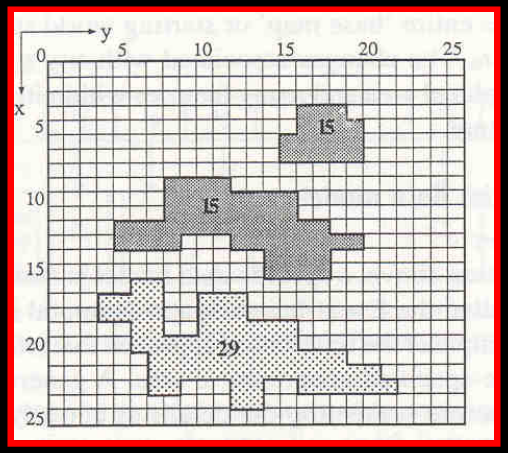


Source: AHPS http://water.weather.gov/precip/

Intervals - event based spatio-temporal model

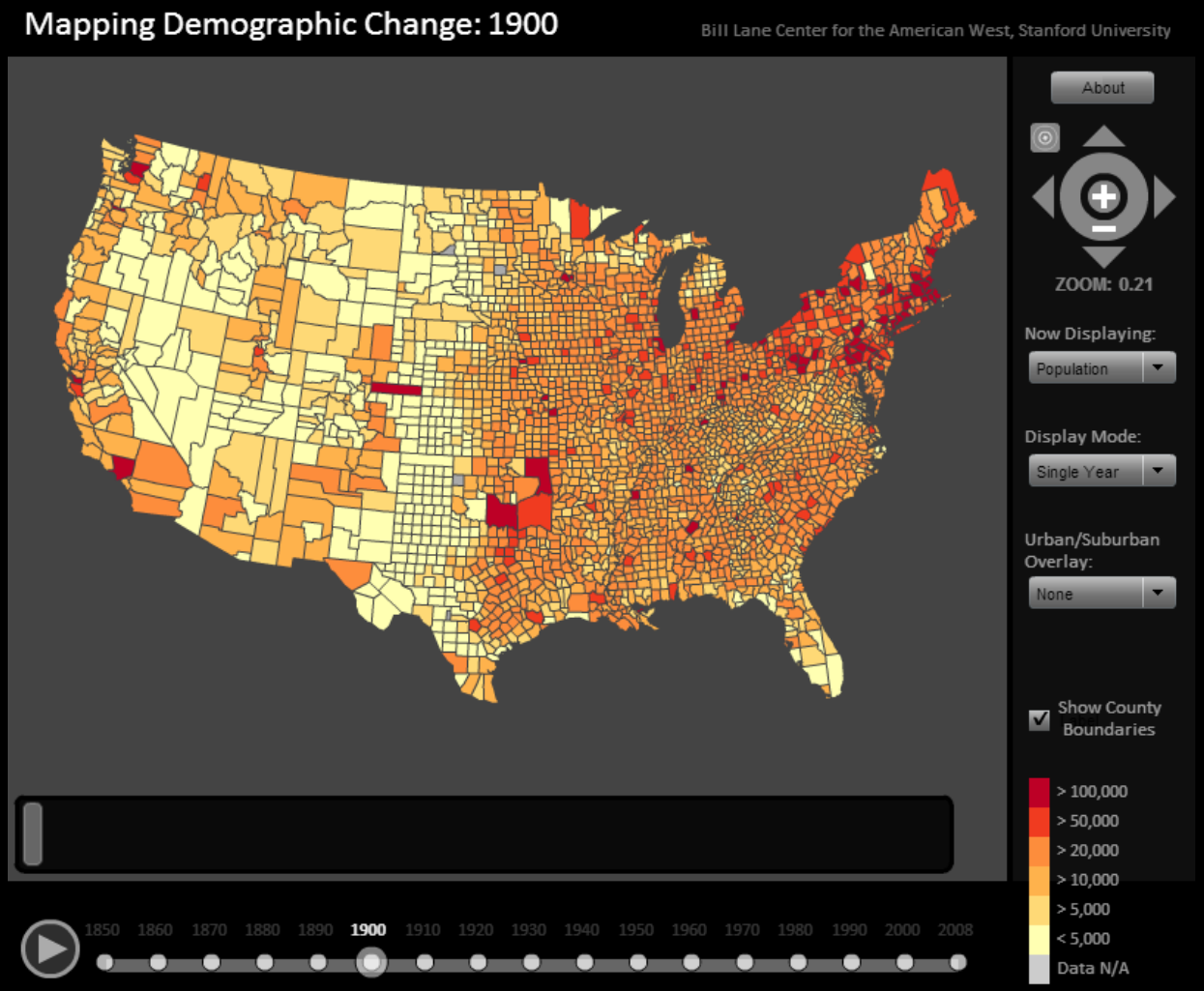


event 1



See: Peuquet and Duan (1995)
http://www.tandfonline.com/doi/abs/10.1080/02693799508902022

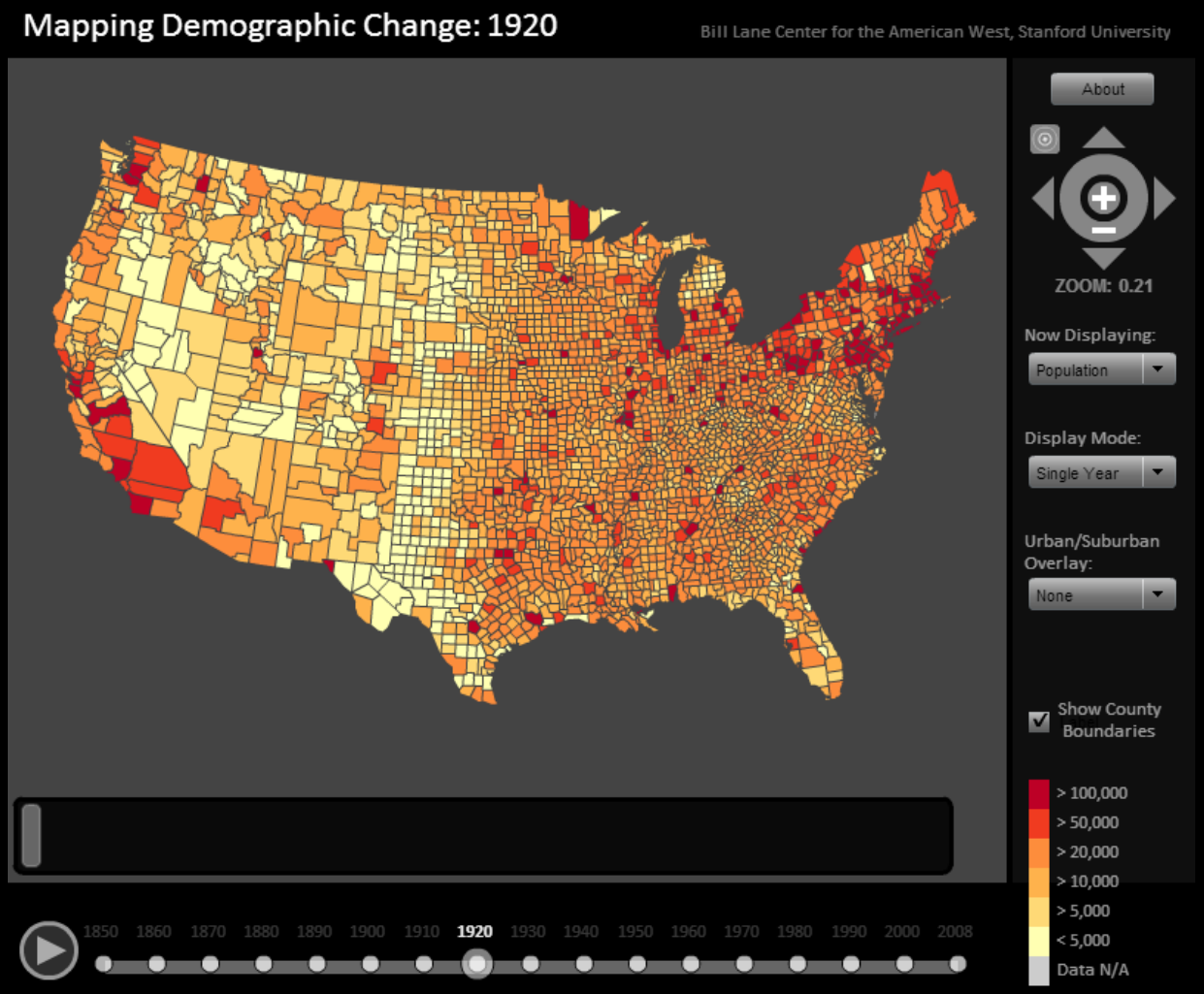
Timestamps for regular intervals (Time Slices)



Data: NHGIS https://www.nhgis.org/

http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

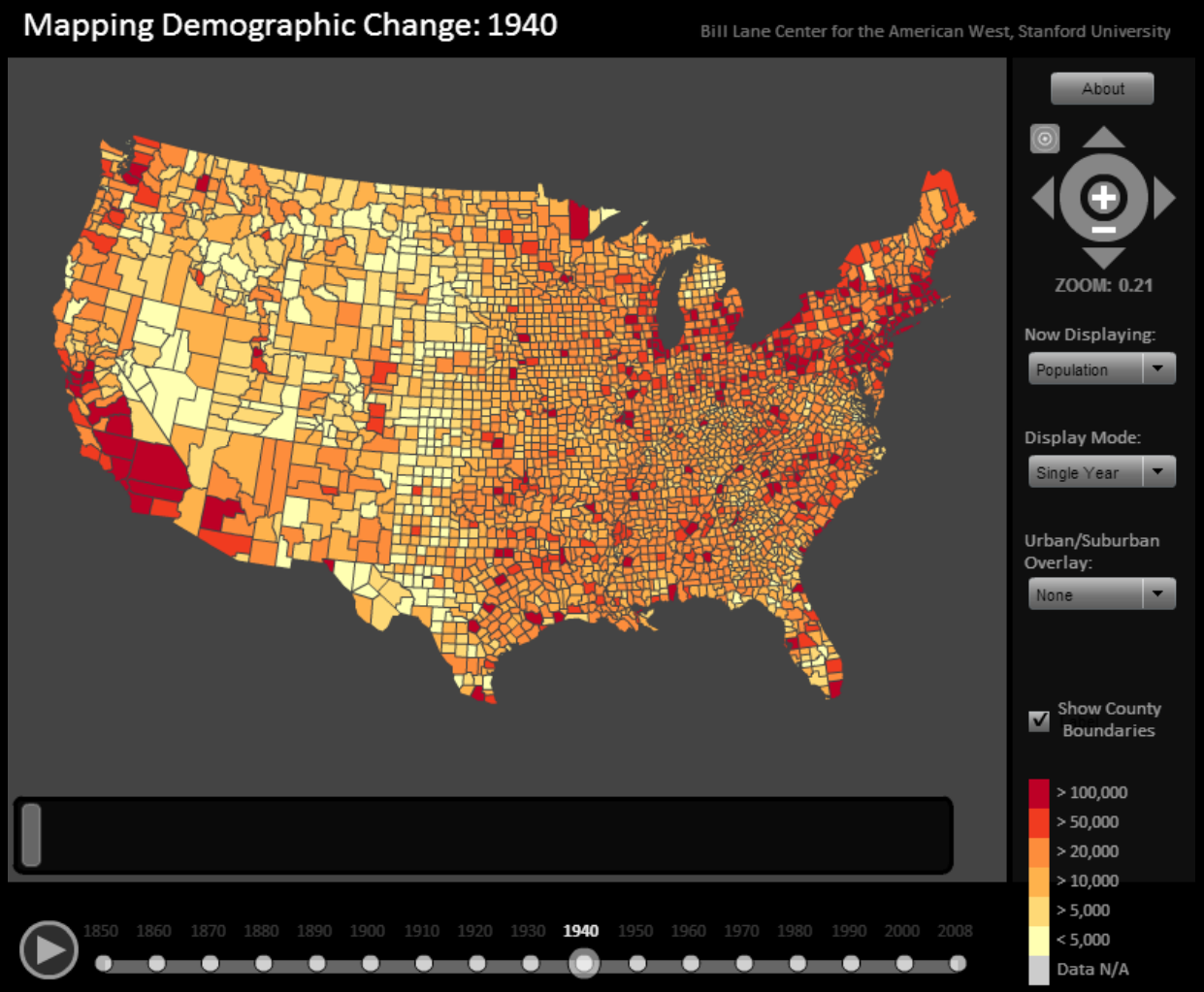
Timestamps for regular intervals (Time Slices)



Data: NHGIS https://www.nhgis.org/

http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

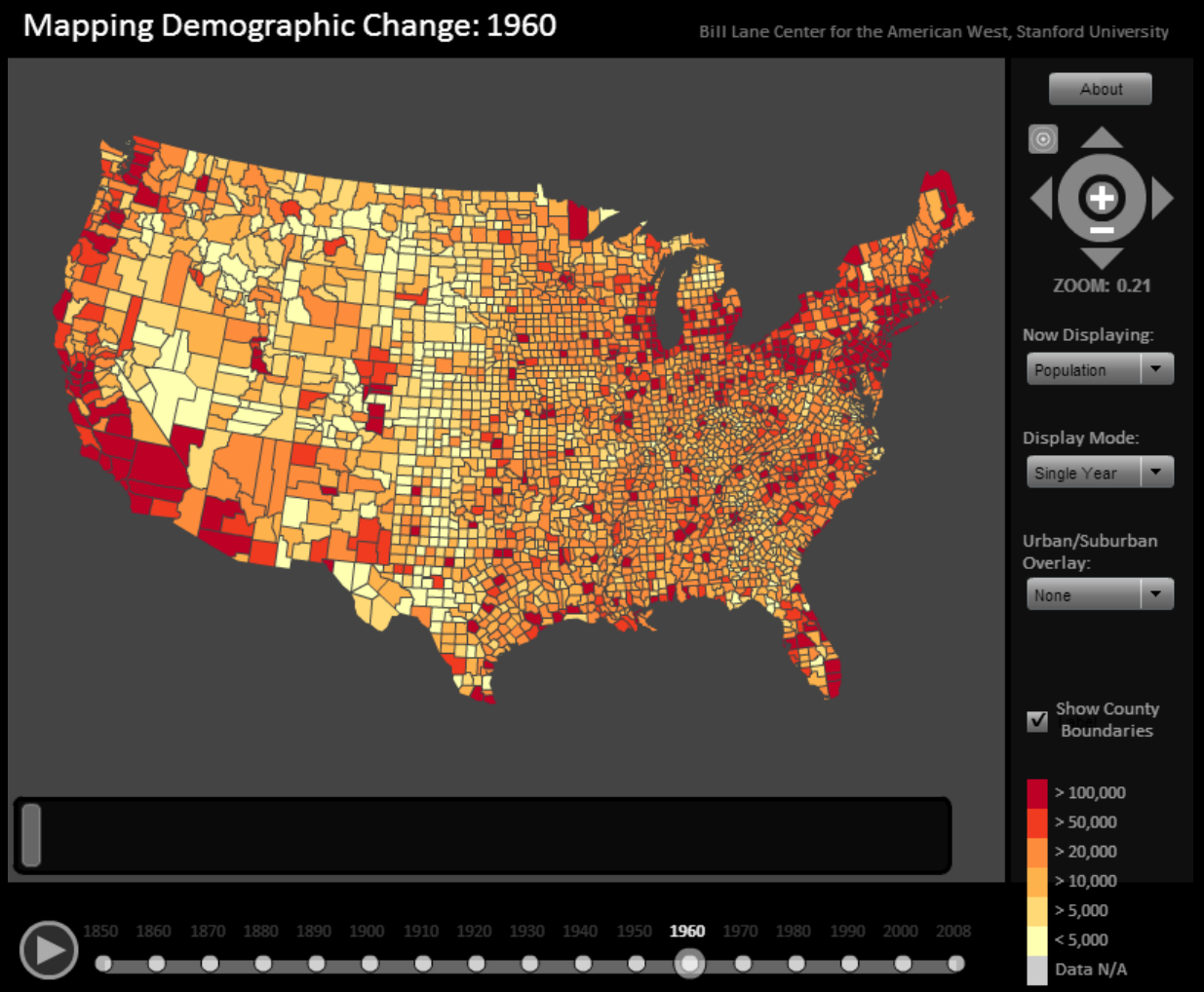
Timestamps for regular intervals (Time Slices)



Data: NHGIS https://www.nhgis.org/

http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

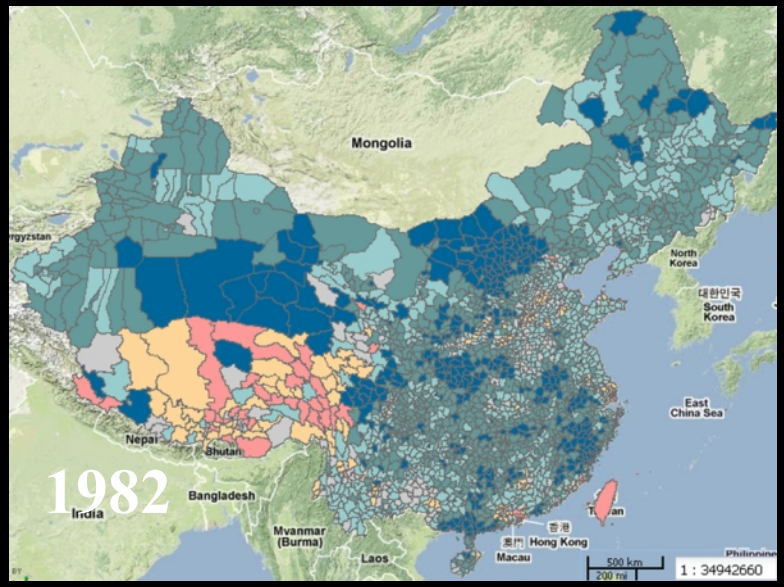
Timestamps for regular intervals (Time Slices)

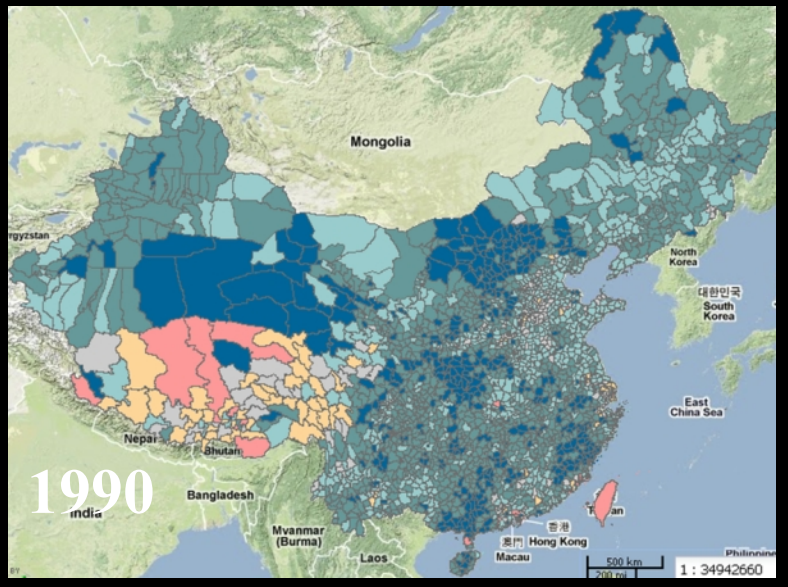


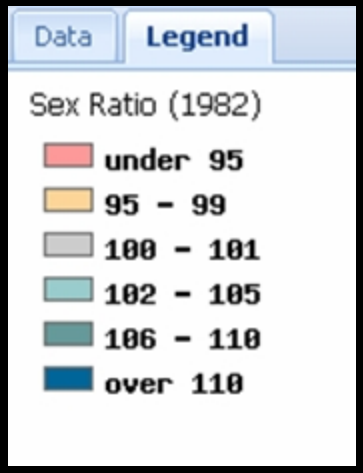
Data: NHGIS https://www.nhgis.org/

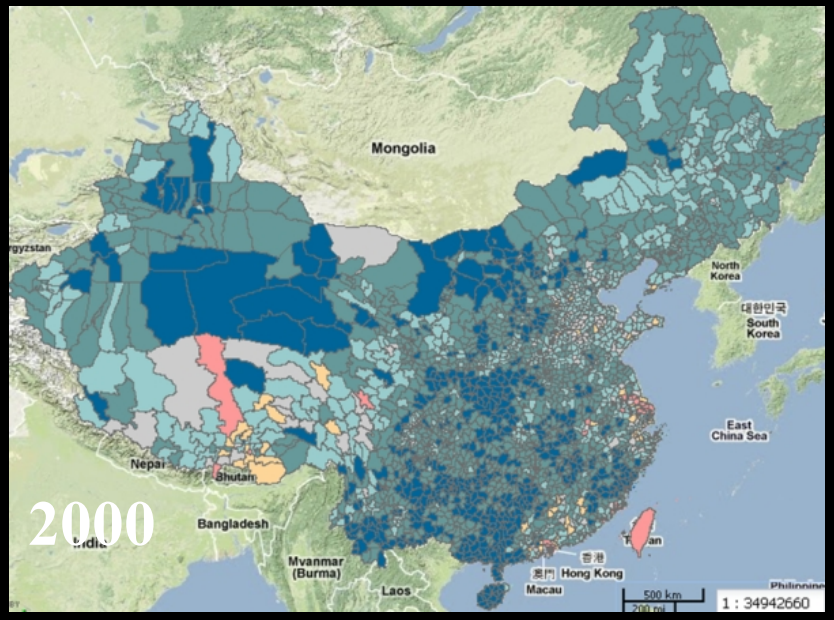
http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

Time slices - cross time classification

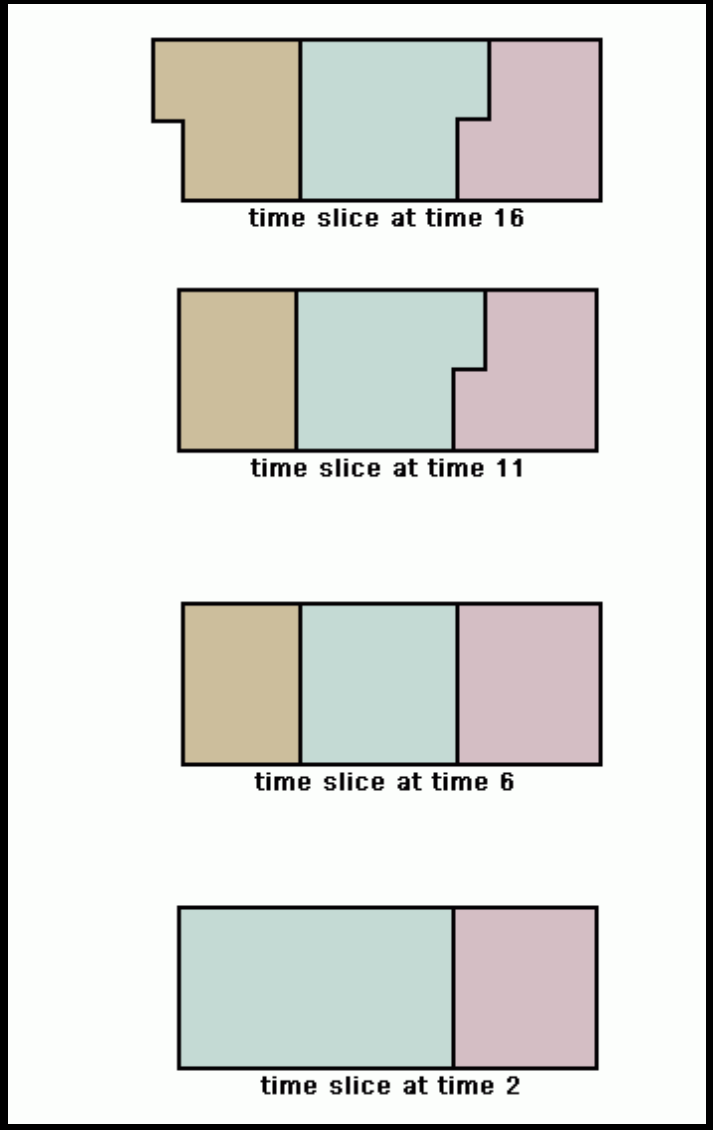




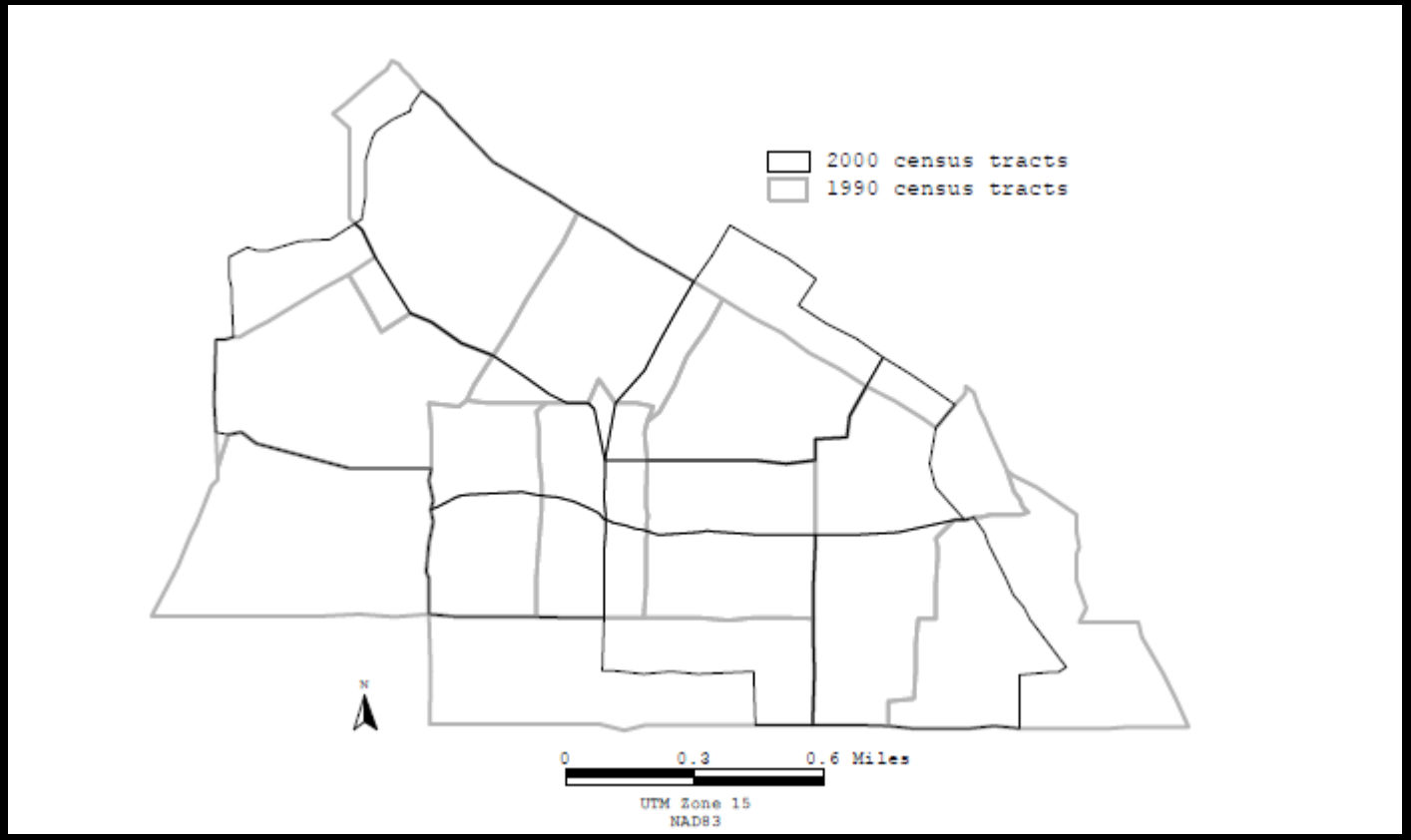




Time Slice = separate dataset for each specific interval

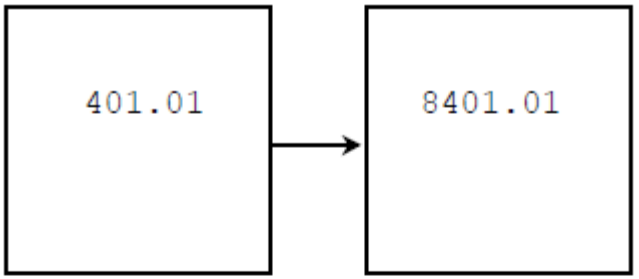


beware of the MAUP

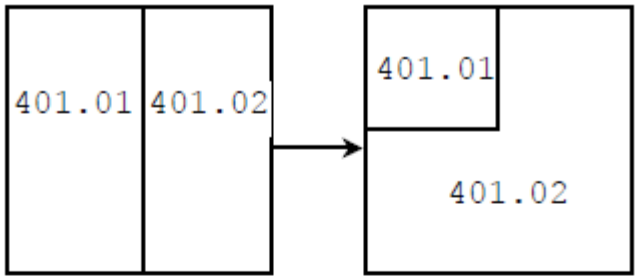


See "NHGIS" McMaster, et al (2005)
http://www.cartesia.org/geodoc/icc2005/pdf/oral/TEMA14/Session%203/ROBERT%20MCMASTER.pdf

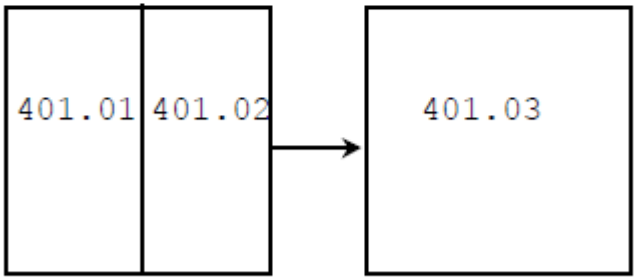
Typology of MAUP



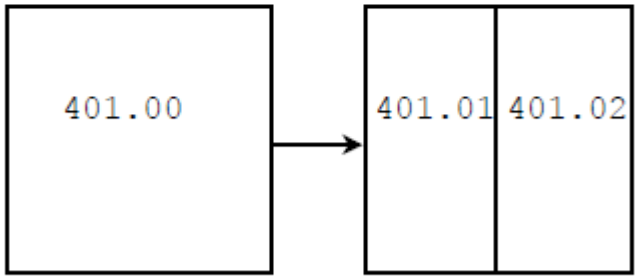
(a) Name change: changes the number of a geographical unit without a boundary change



(b) Transfer: moves part of one geographical unit to another unit



(c) Merger: combines two or more geographical units into one unit



(d) Division: splits one geographical unit into two or more units

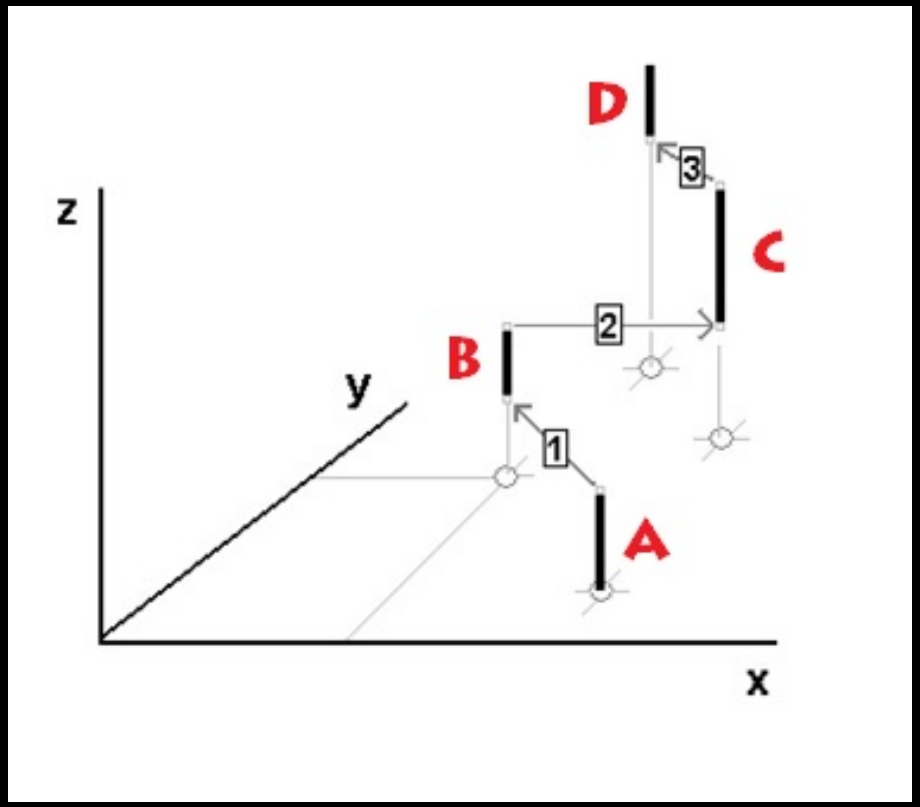
See "NHGIS" McMaster, et al (2005)
http://www.cartesia.org/geodoc/icc2005/pdf/oral/TEMA14/Session%203/ROBERT%20MCMASTER.pdf

Begin and end dates at irregular intervals

object	begin	end	precBy
A	t1	t2	
B	t2	t3	A
C	t3	t4	B
D	t4	t5	C

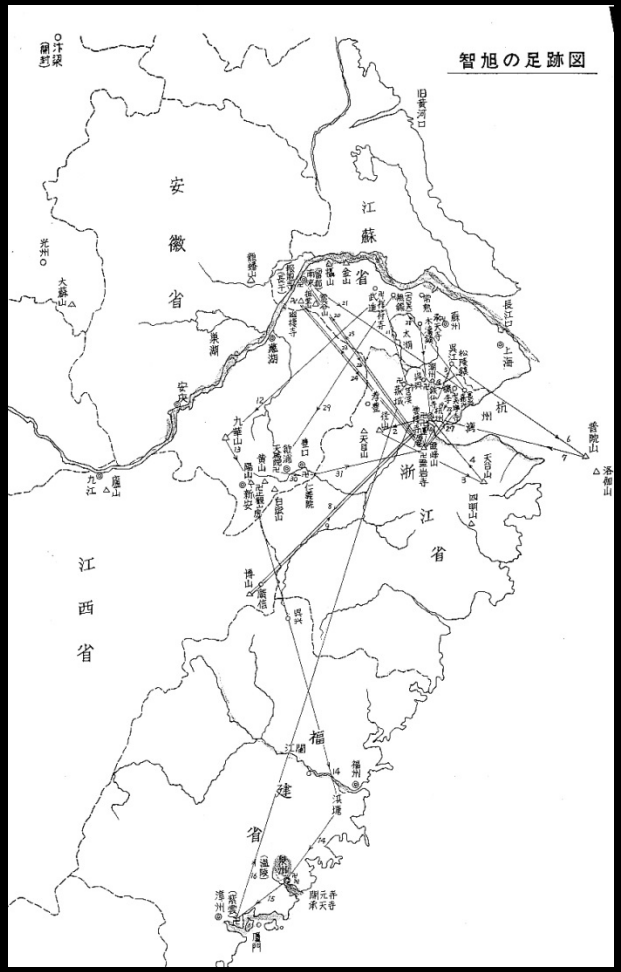
Begin and end dates – using the z axis for time

object	begin	end	precBy
A	t1	t2	
B	t2	t3	A
C	t3	t4	B
D	t4	t5	C



spatio-temporal objects

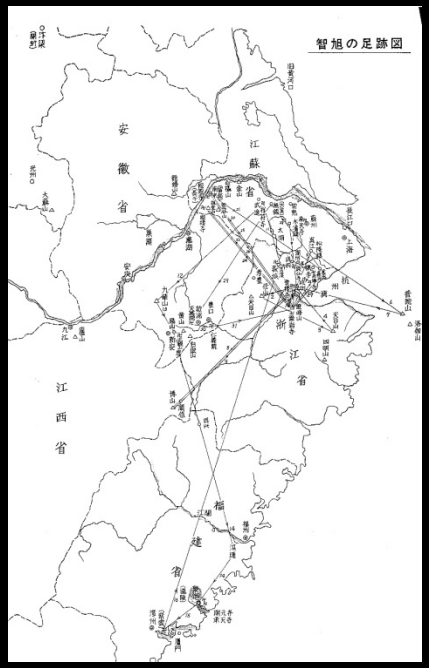
Sequence of points to show movement over time

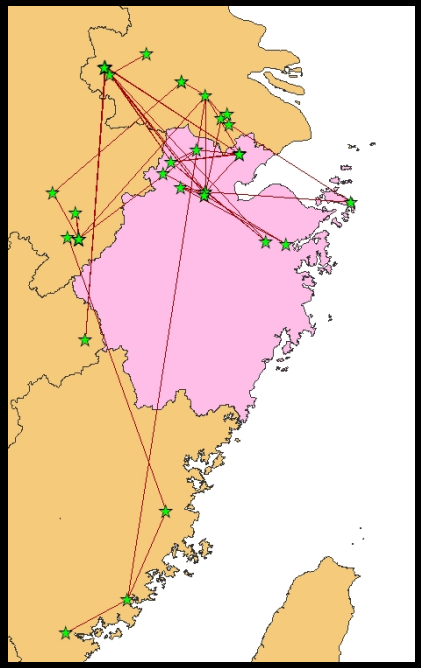


Based on research by Beverly Faulks
http://www.fas.harvard.edu/~chgis/work/docs/papers/Berman_ModelingNetworks_Bochum07.pdf

Time sequence does not have to be equal intervals

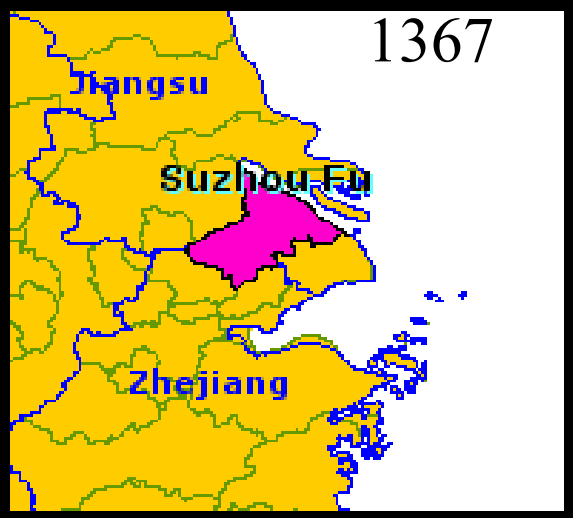
place_id	year	season	sequence	source	type_id	type_description	chrono_events_notes
ouyi_1	1599		1	autobio	1	birth	
ouyi_3	1622	summer	2	ZL.8.2.1-8, autobio	10	Yogacara (唯識論)	
ouyi_3	1622	summer	3	ZL.8.2.1-8, autobio	9	received teachings	
ouyi_2	1622	late fall	4	autobio	4	engaged in meditation	
ouyi_6	1622		5	ZL 8.2.1	25	other	first met Xinyi Dazhen 新
ouyi_6	1623		6	選佛譜序	18	divination game	傳燈[選佛圖]隨喜
ouyi_4	1623	spring	7		25	other	謁幽溪傳燈 - pay respe
ouyi_4	1623	fall	8		4	engaged in meditation	

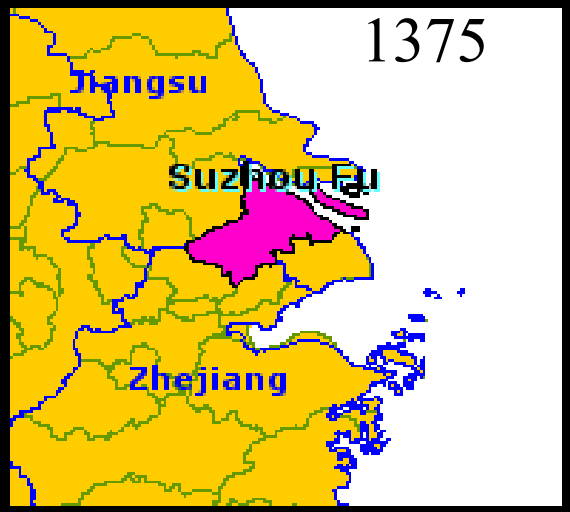


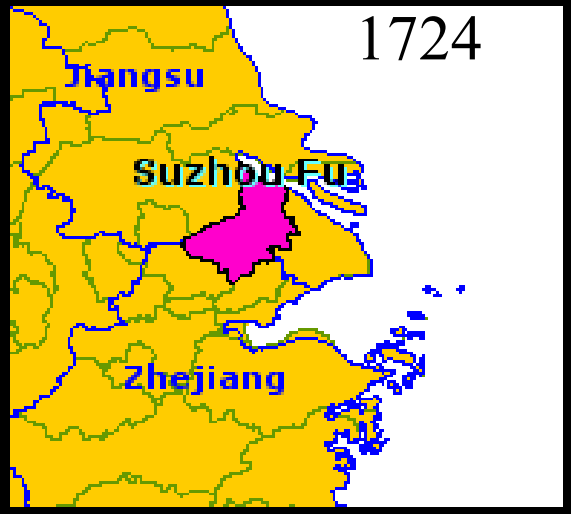


Animation:
http://www.fas.harvard.edu/~chgis/work/docs/papers/ouyi_flash_demo.swf

Begin-end dates for areal units as ST objects







Source: CHGIS http://www.fas.harvard.edu/~chgis/

Historical Source Notes

Source Note: 苏州府（1375-1723年）界线
明洪武八年（1375），扬州府崇明县来属，府境扩大。清顺治二年（1645）地入清，属江南省。康熙六年（1667）为江苏省会。清雍正二年（1724），太仓州升为直隶州，境域缩小。
明洪武八年（1375年），扬州府崇明县来属，[1]府境扩大。洪武十一年正月（1378年2月）隶京师。[2]永乐元年正月（1421年2月）属南京。洪熙元年三月戊戌（1425年4月16日）复属京师。[3]正统六年十一月甲午（1441年11月14日）复属南京（南直隶）。[4]弘治十年正月己巳（1497年2月11日）增领太仓州，崇明县改隶太仓州。[5]至明末，苏州府领吴、长洲、昆山、常熟、吴江、嘉定6县、太仓州（领崇明县）。清顺治二年闰六月乙巳（1645年8月19日）地入清，属江南省。[6]康熙六年七月甲寅（1667年8月30日）以原江南省右布政使司为江苏布政使司，[7]府属江苏省，江苏巡抚及布政、按察两使治此，为江苏省会。[8]雍正二年九月甲辰（1724年10月20日），增领元和、震泽、昭文、新阳、镇洋、新阳6县。[9]治所为吴、长洲、元和3县。[10]清雍正二年（1724），太仓州升为直隶州，镇洋、嘉定、宝山、崇明4县往属太仓直隶州，境域缩小[11]。

Tables

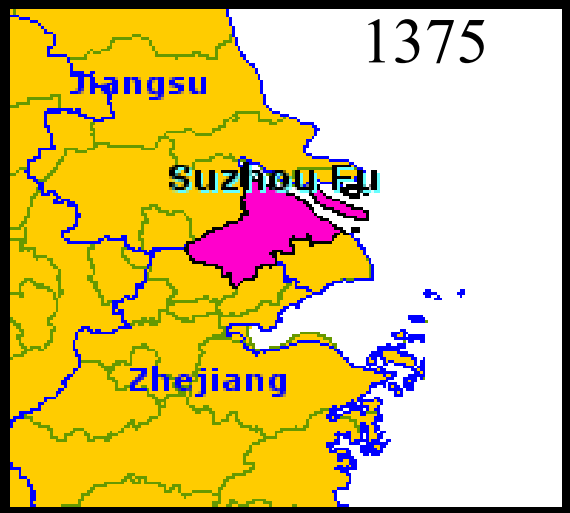
Sys-ID	Hist-Place	From	To
90244	Suzhou Fu	1367	1374
90245	Suzhou Fu	1375	1723
90246	Suzhou Fu	1724	1911
333320501	Shzhou Shi	1990	1990

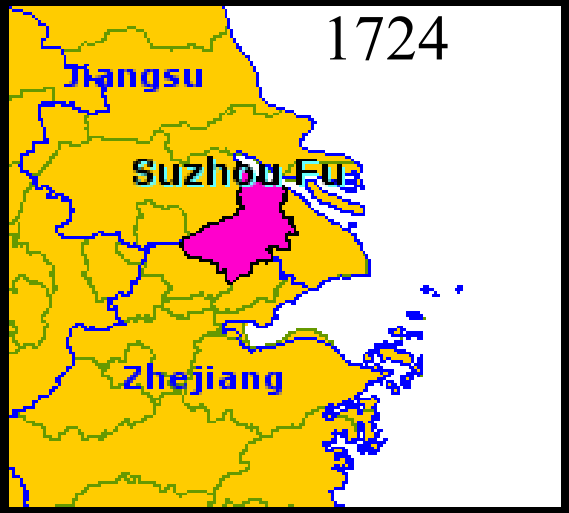
Sys-ID	Place-Name	Prec-ID	Prec-Name
90245	Suzhou Fu	90244	Suzhou Fu
90245	Suzhou Fu	40385	Chongming Zhou

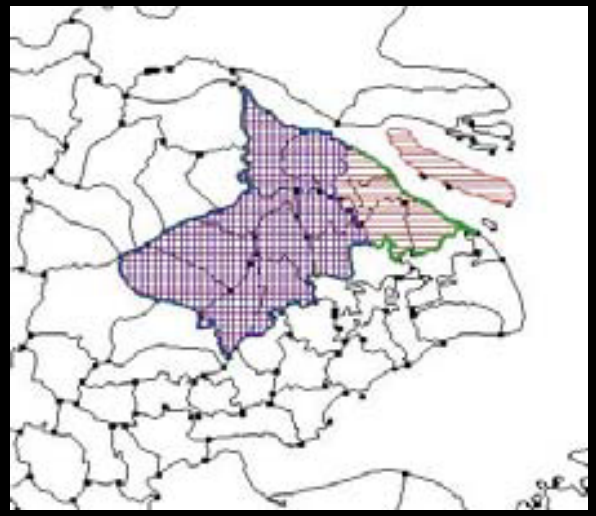
Sys-ID	Name	Part-Of	From	To
90245	Suzhou Fu	Jiangnan Province	1645	1667
90245	Suzhou Fu	Jiangsu Province	1667	1911

Spatial Objects (Regions)

return of the MAUP

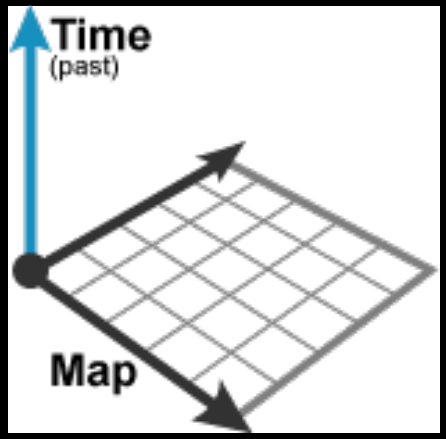


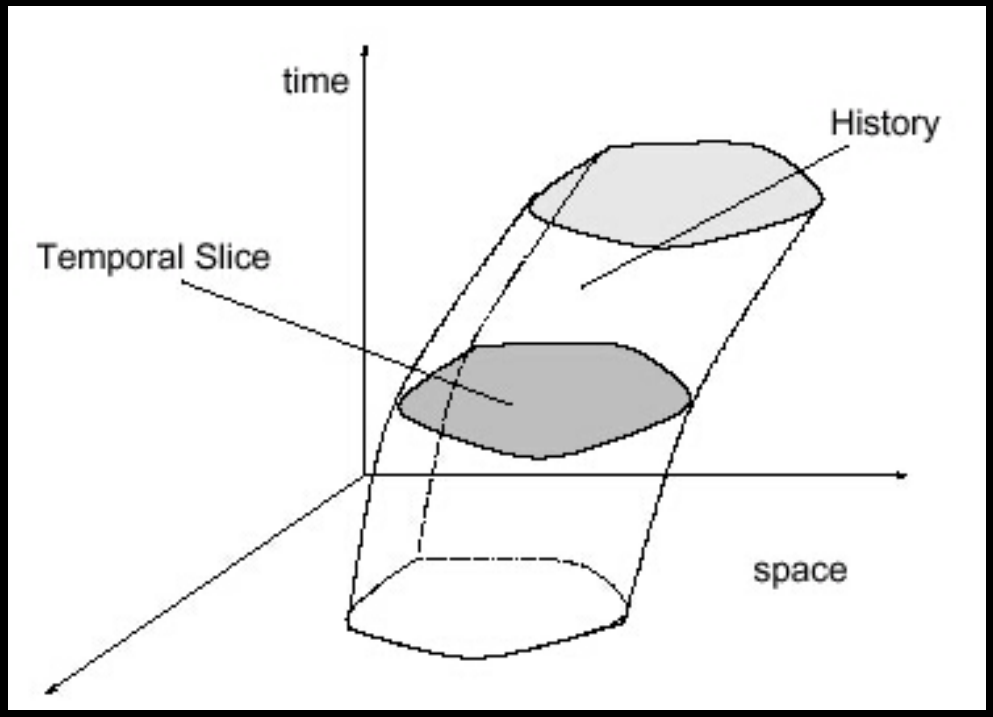




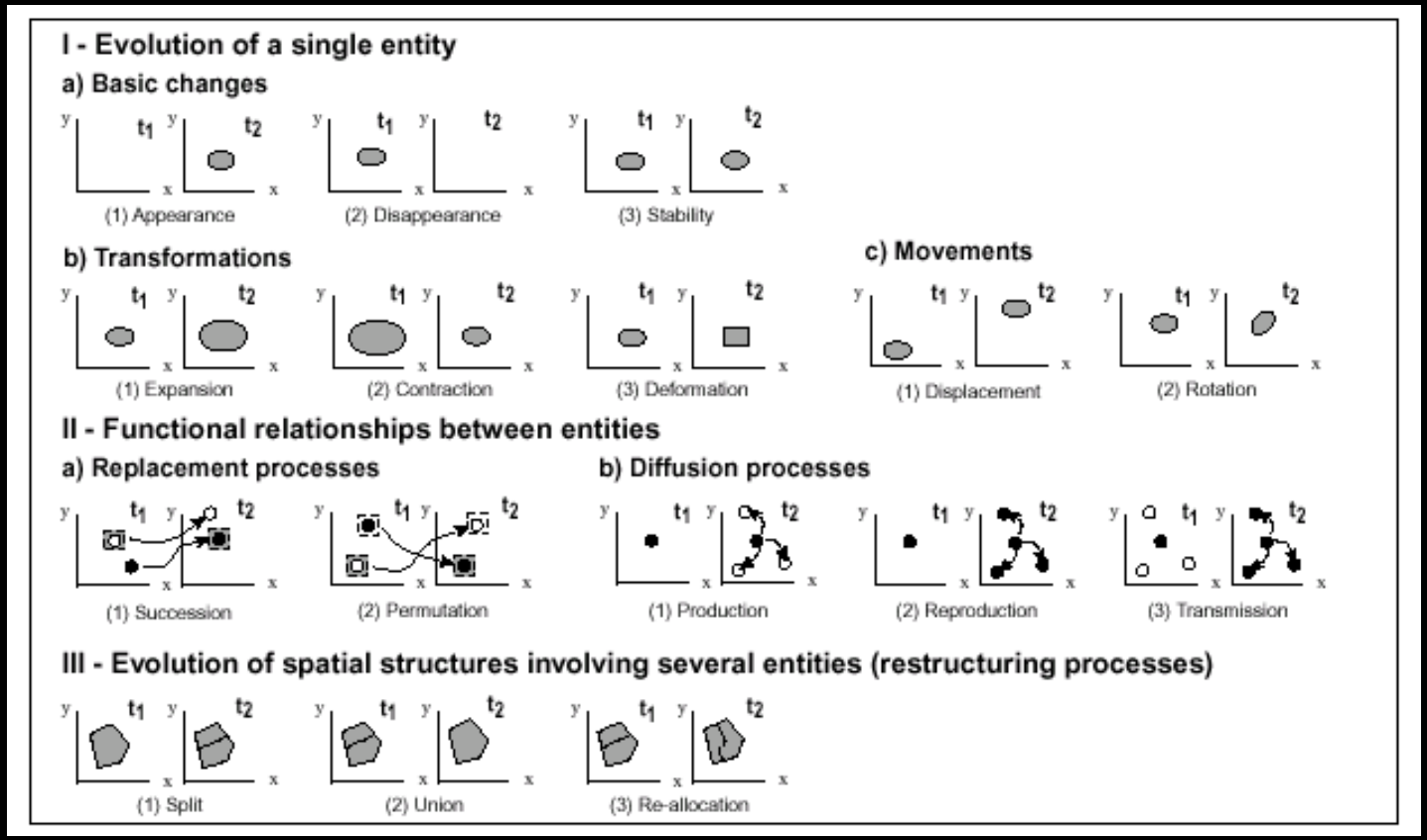
See “Methods for Space Time Analysis” Henderson and Berman (2003)
http://proceedings.esri.com/library/userconf/proc03/p0833.pdf

Modeling areal units as they change over time



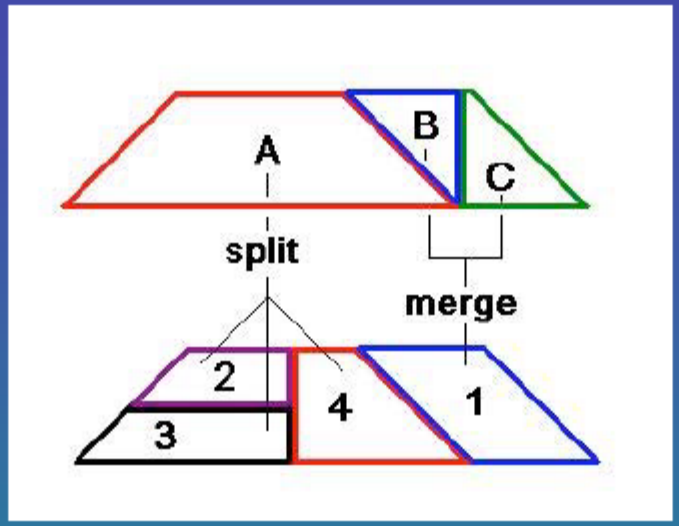


Logic of spatio-temporal objects as areal units



See Claramunt, et al (1997)
http://www.intelligentmodelling.org.uk/Papers/rttg-publ30.pdf

Hierarchical administrative units: sequence of changes



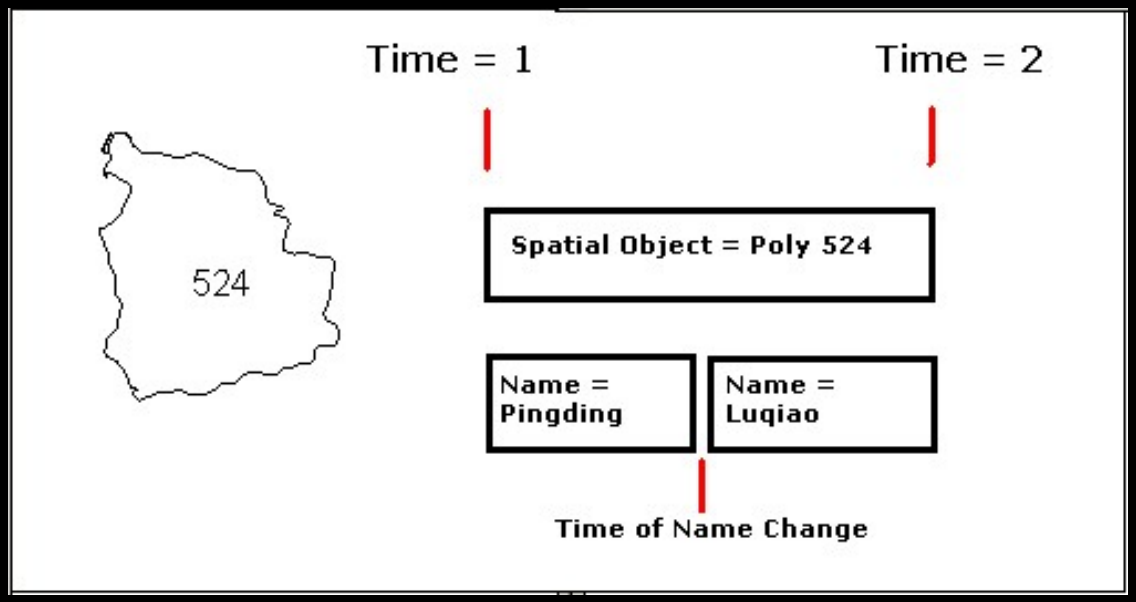
Historical Instances Table

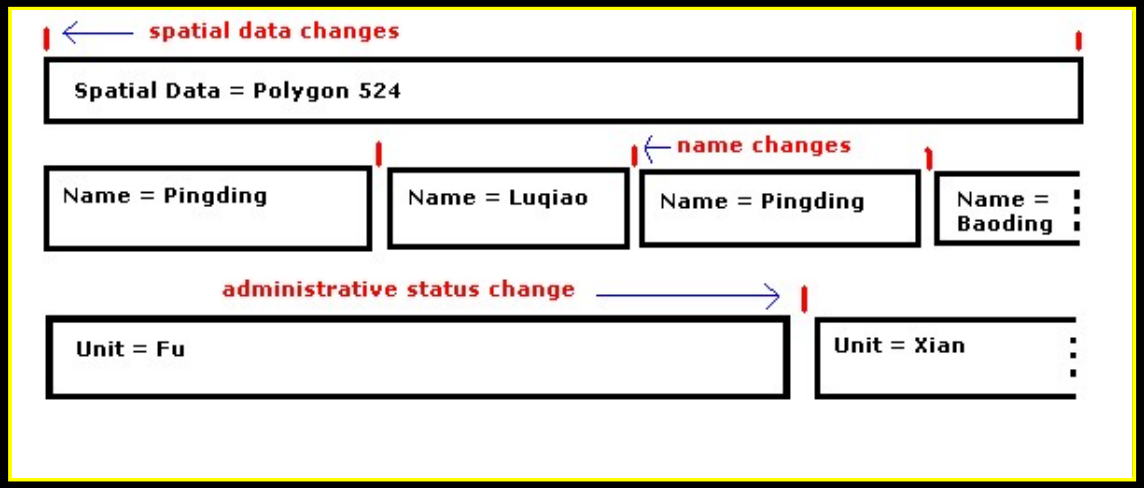
sys-id	hist-place
5001	A
5002	B
5003	C
5004	1
5005	2
5006	3
5007	4

Temporal Sequence Table

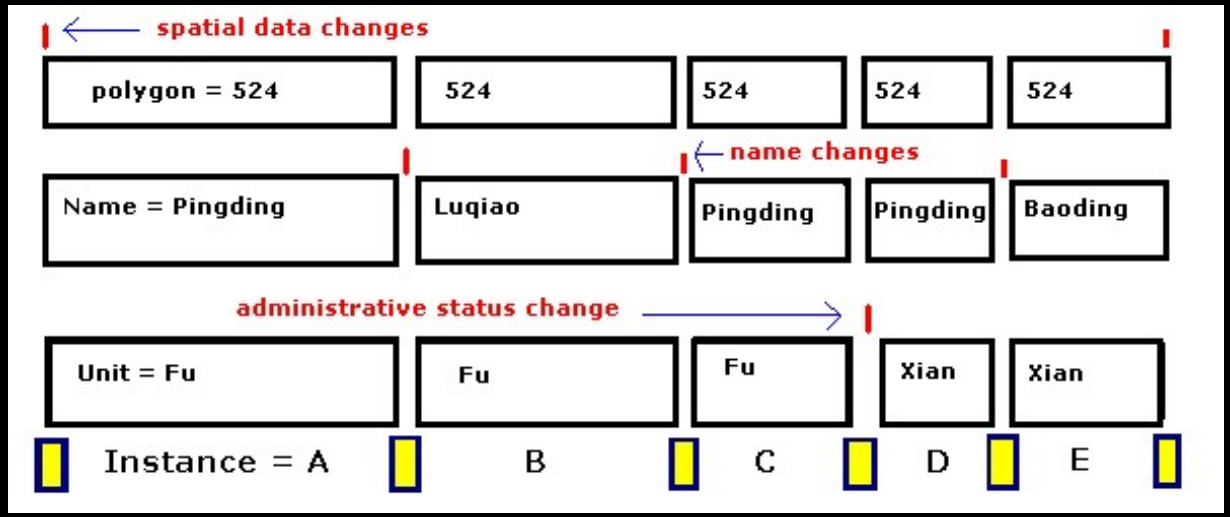
sys-id	place-name	prec-by	prec-by-name
5004	1	5002	B
5004	1	5003	C
5005	2	5001	A
5006	3	5001	A
5007	4	5001	A

Hierarchical administrative units - data modelling





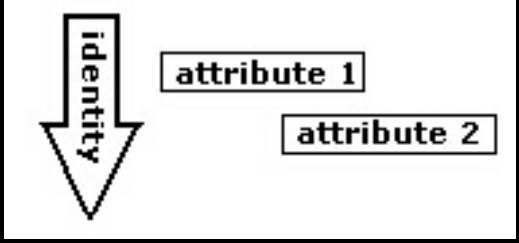
Hierarchical administrative units - historical instances

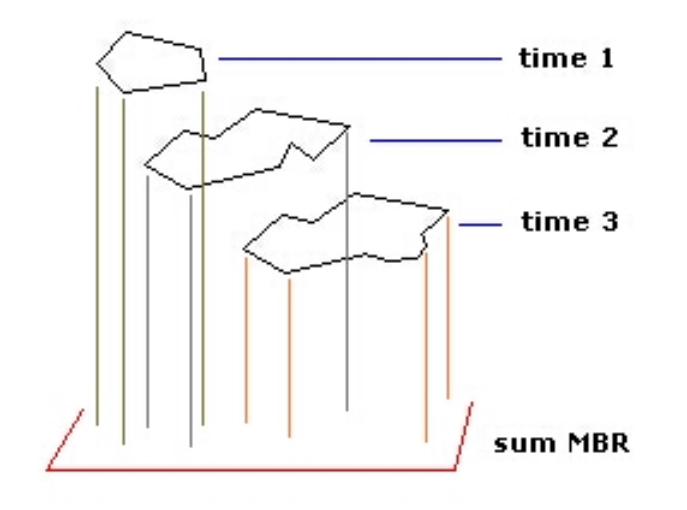


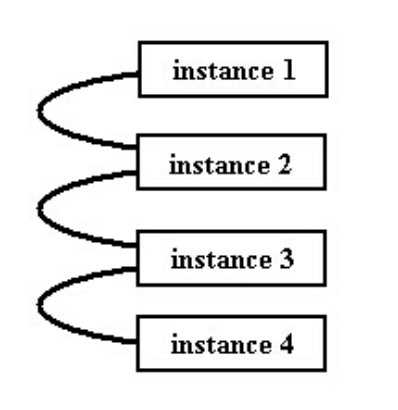
name	begin	end	preceded by
A	time1	time2	
B	time2	time3	A
C	time3	time4	B
D	time4	time5	C
E	time5	time6	D

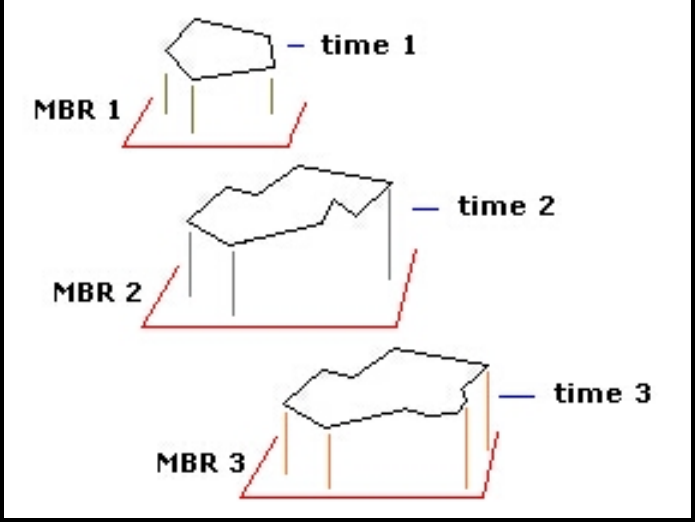
See Berman (2003)
http://www.fas.harvard.edu/~chgis/work/docs/papers/v2_chgis_data_model.pdf

Entities that change vs. historical instances that link

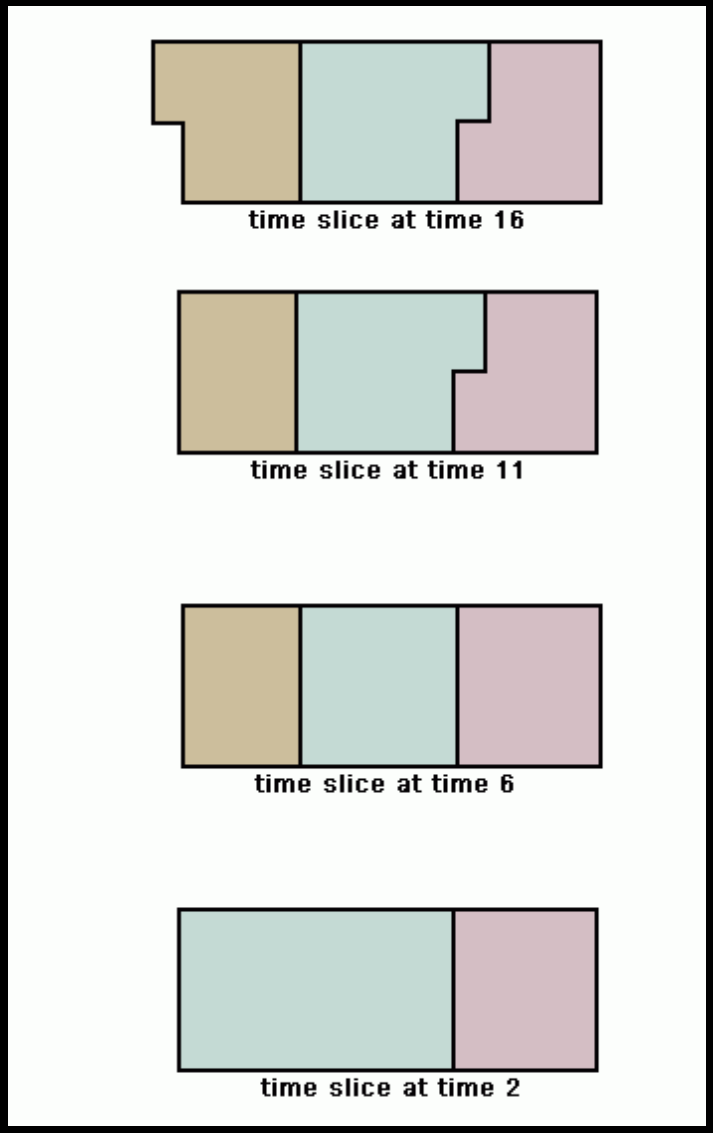


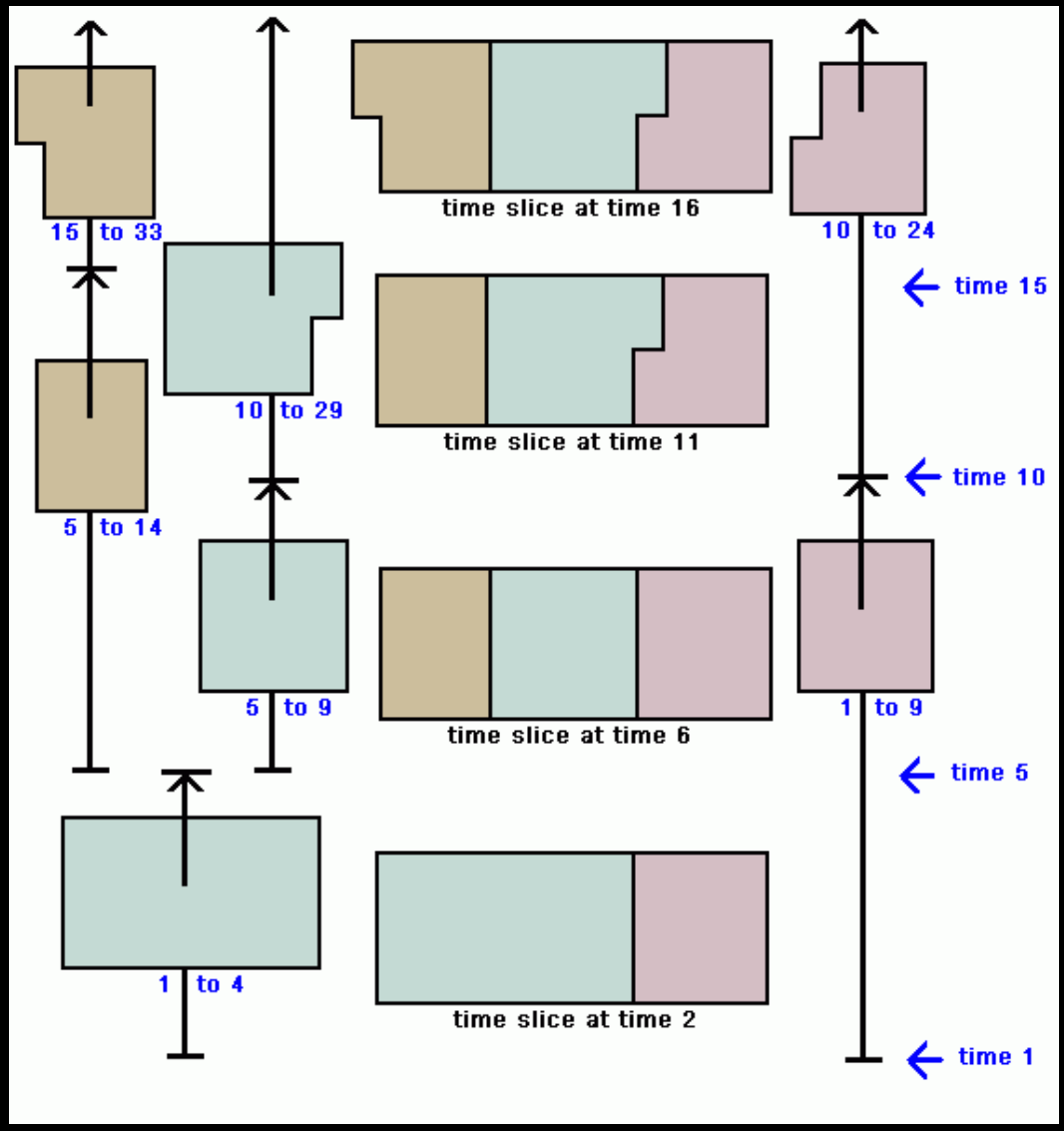




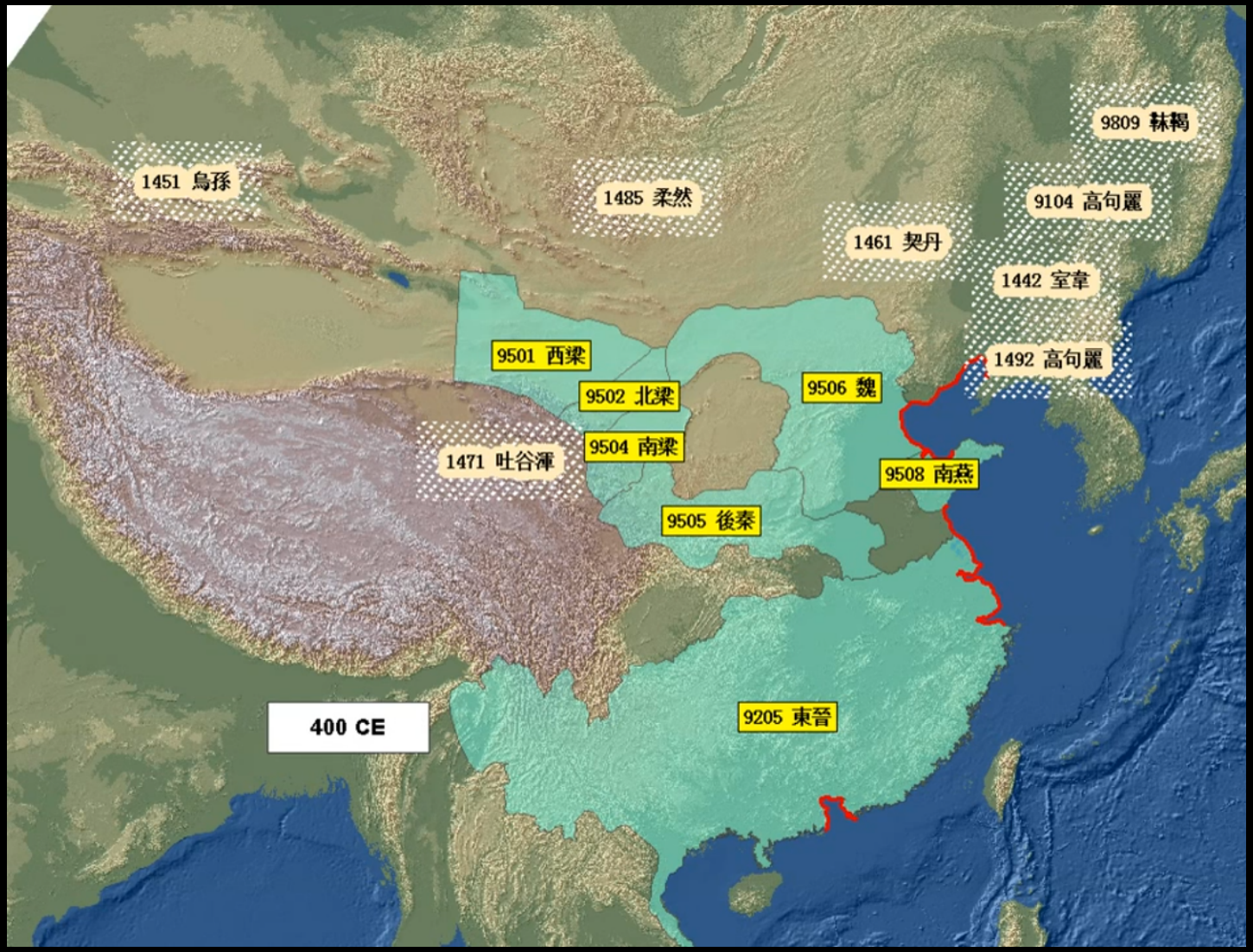


Time slices vs. Asynchronous instances (Time series)



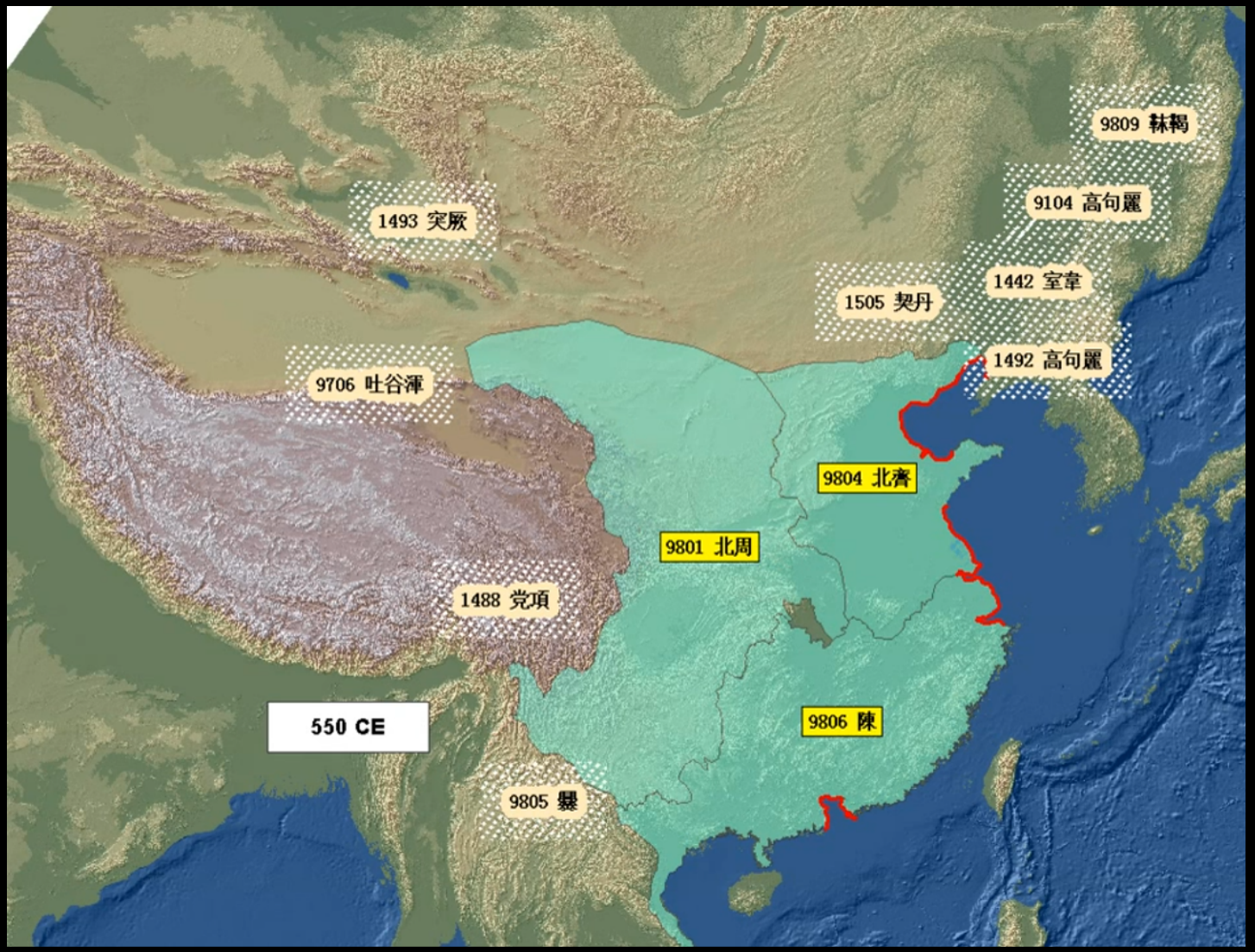


Asynchronous instances (Time series) -> detailed animations



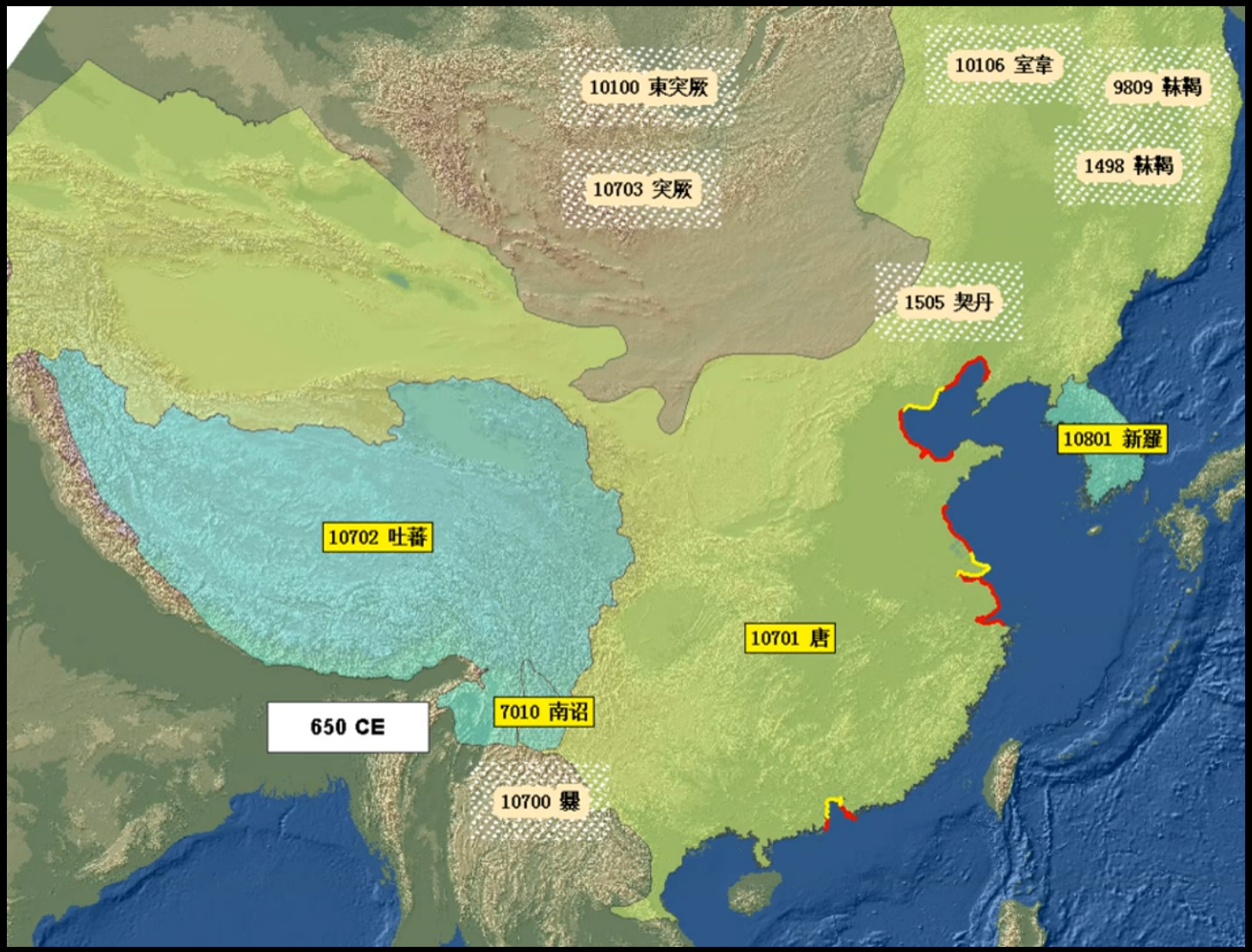
Source: working draft for ChinaX Course (Fall 2013)

Asynchronous instances (Time series) -> detailed animations



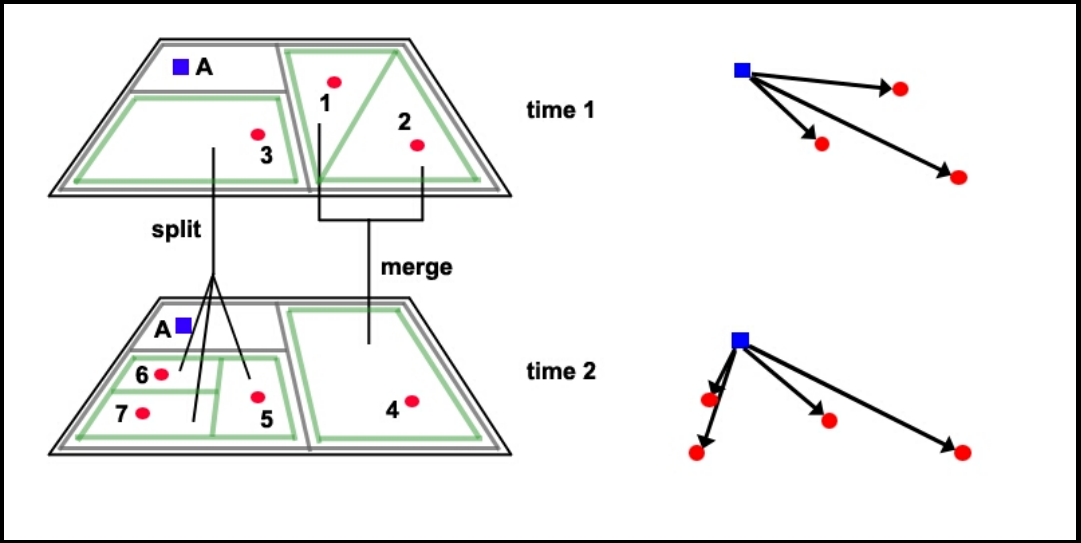
Source: working draft for ChinaX Course (Fall 2013)

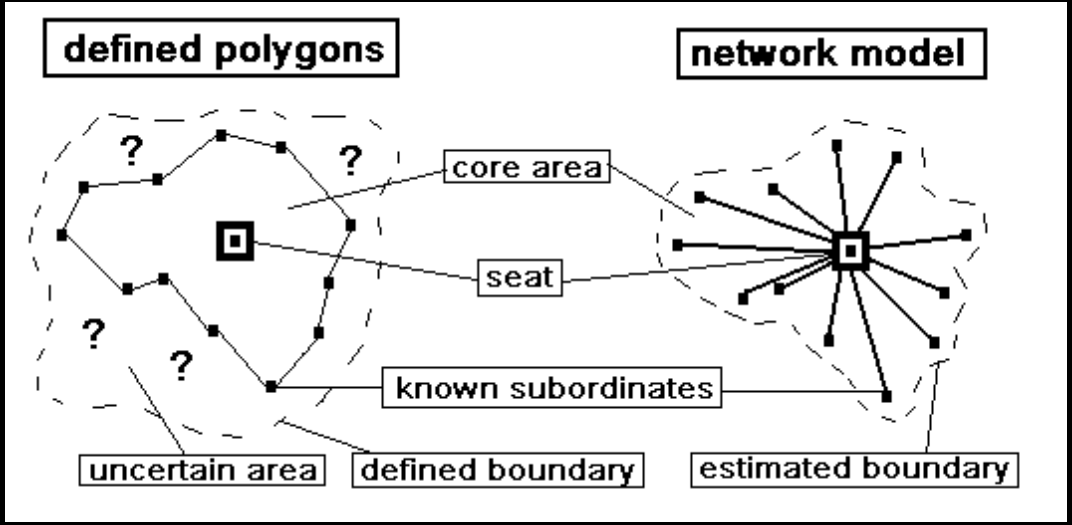
Asynchronous instances (Time series) -> detailed animations



Source: working draft for ChinaX Course (Fall 2013)

Asynchronous instances: areal units vs. network of nodes





Network model relies on the parent-child relationships

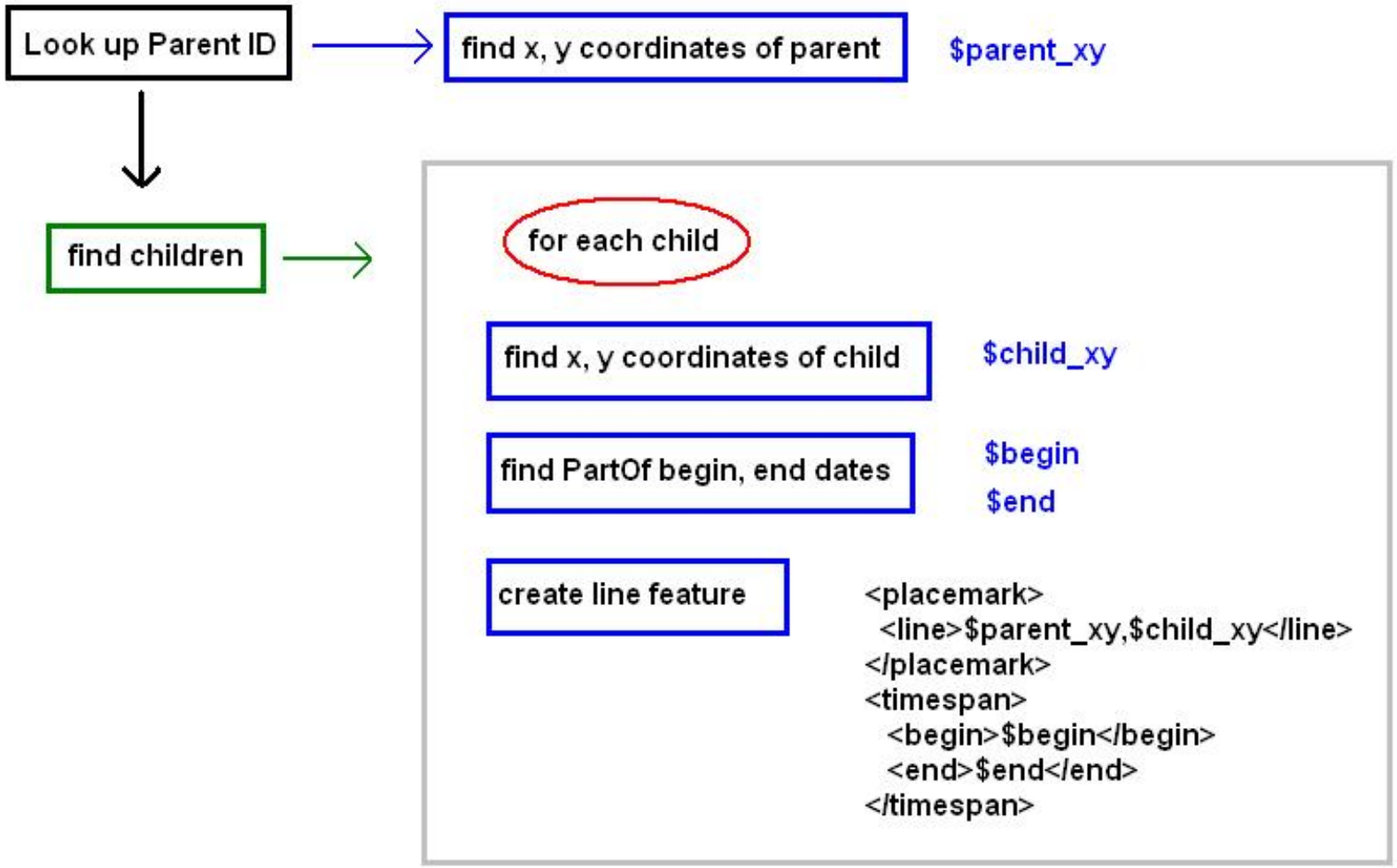
Historical Instances Table

sys-id	hist-place	begin	end
333	Province T	1200	1350
334	Prefecture A	1200	1249
335	Prefecture B	1250	1350
336	Prefecture C	1200	1350
337	County X	800	1500
338	County Y	1200	1320
339	County Z	1321	1340
340	Town 1	200	1700
341	Town 2	100	1500

Part-Of Table

sys-id	place-name	part-of	part-of-name	begin	end
334	Prefecture A	333	Province T	1200	1249
335	Prefecture B	333	Province T	1250	1350
336	Prefecture C	333	Province T	1200	1350
337	County X	334	Prefecture A	1200	1249
337	County X	335	Prefecture B	1250	1350
338	County Y	336	Prefecture C	1200	1350
339	County Z	336	Prefecture C	1200	1350
340	Town 1	337	County X	1200	1350
341	Town 2	338	County Y	1300	1320
341	Town 2	339	County Z	1321	1340

Query parent-child relationships to generate network of objects

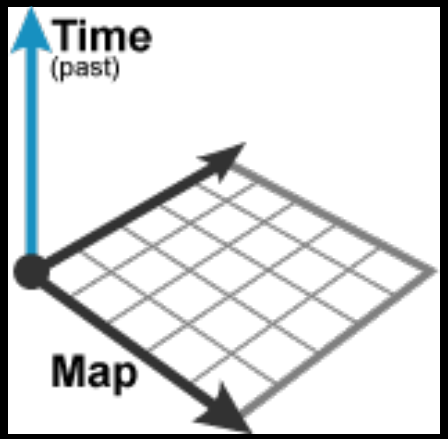


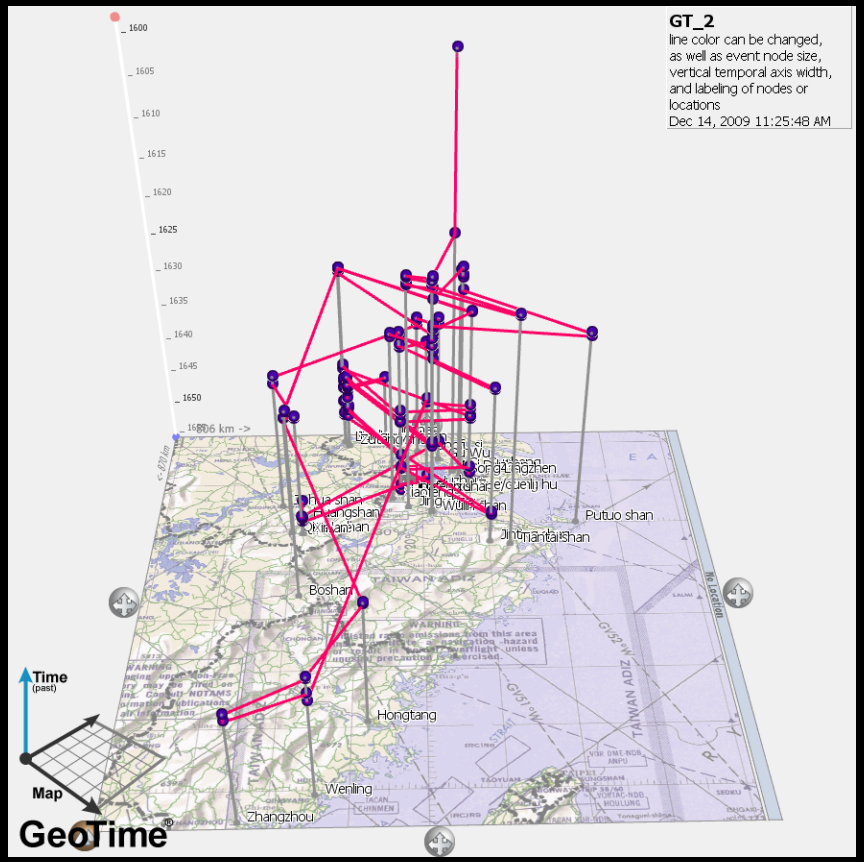
Network model in Google Earth

Data

https://cga-download.hmdc.harvard.edu/publish_web/Geo_Tools/teKML/examples/

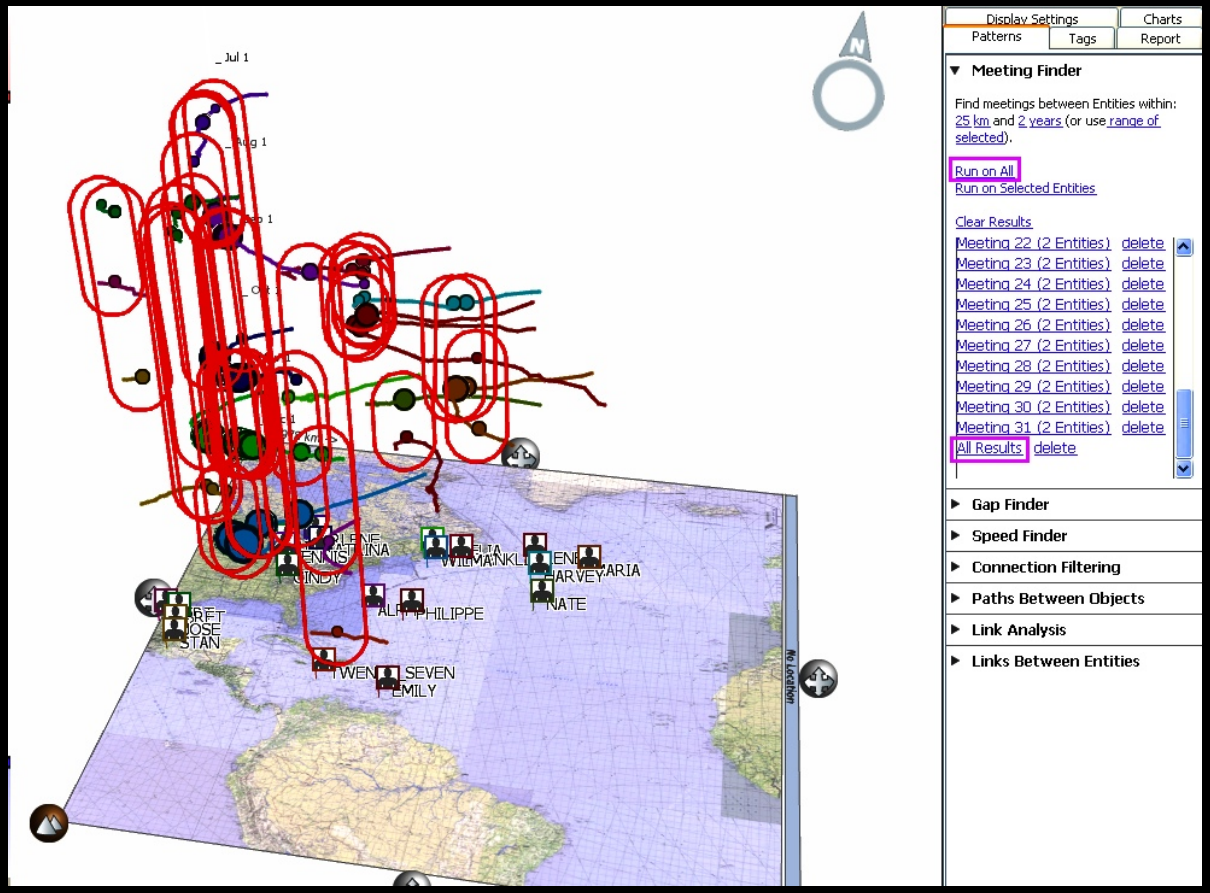
Network model with z-axis for time





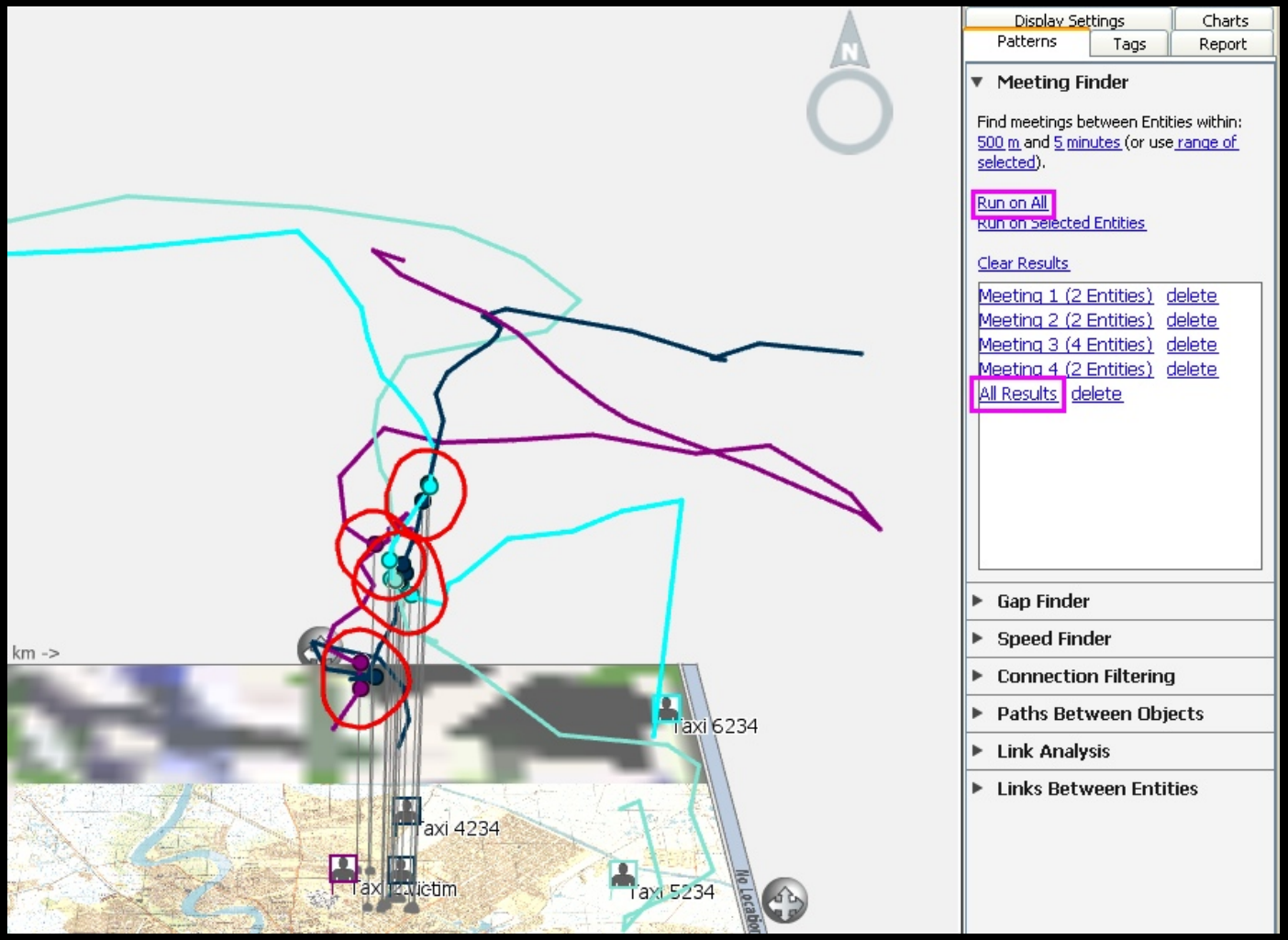
See: https://cga-download.hmdc.harvard.edu/publish_web/GeoTime/

Spatio-temporal queries on x, y, objects



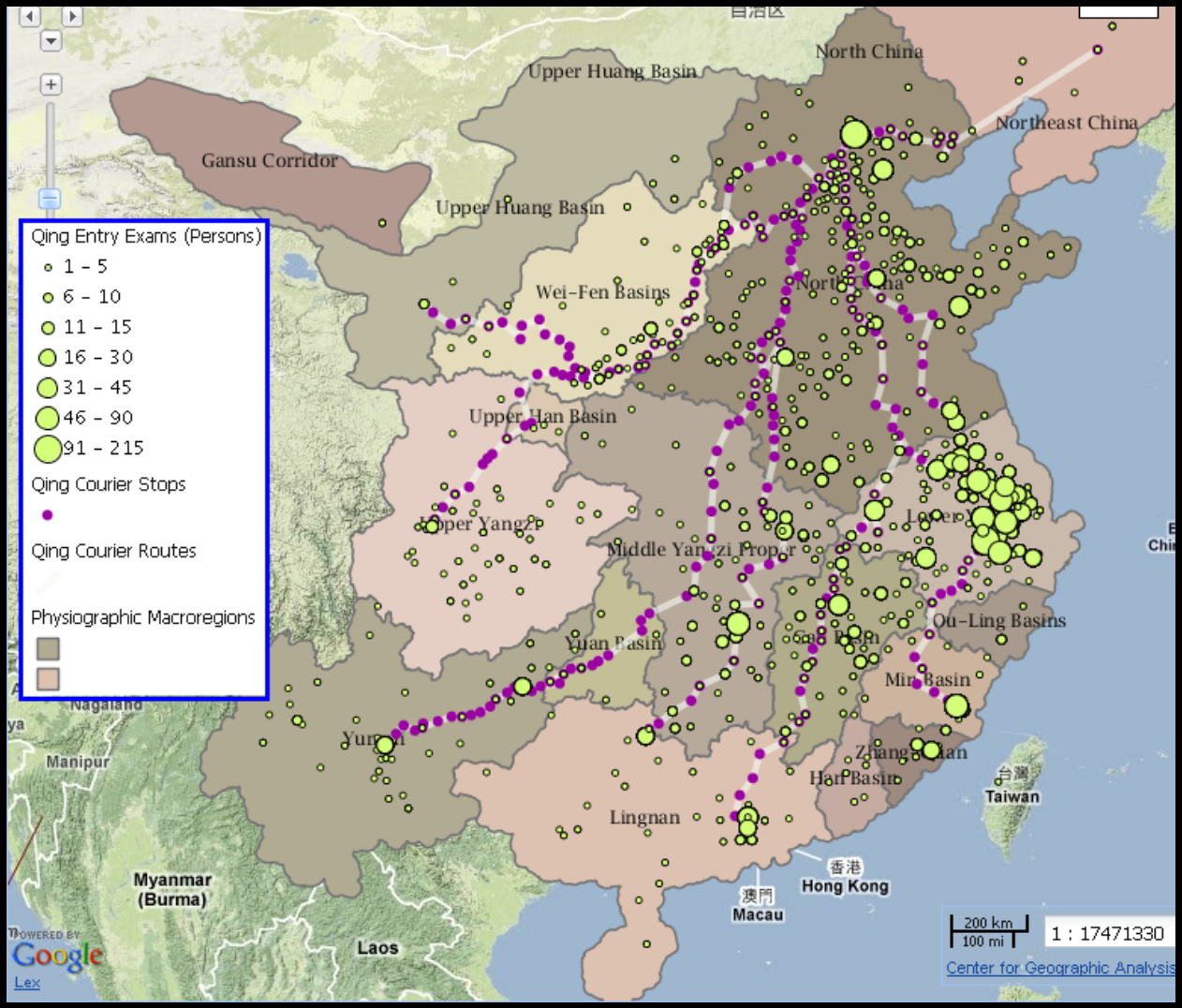
Proximity query (not including temporal filter)

Spatio-temporal queries on x, y, objects



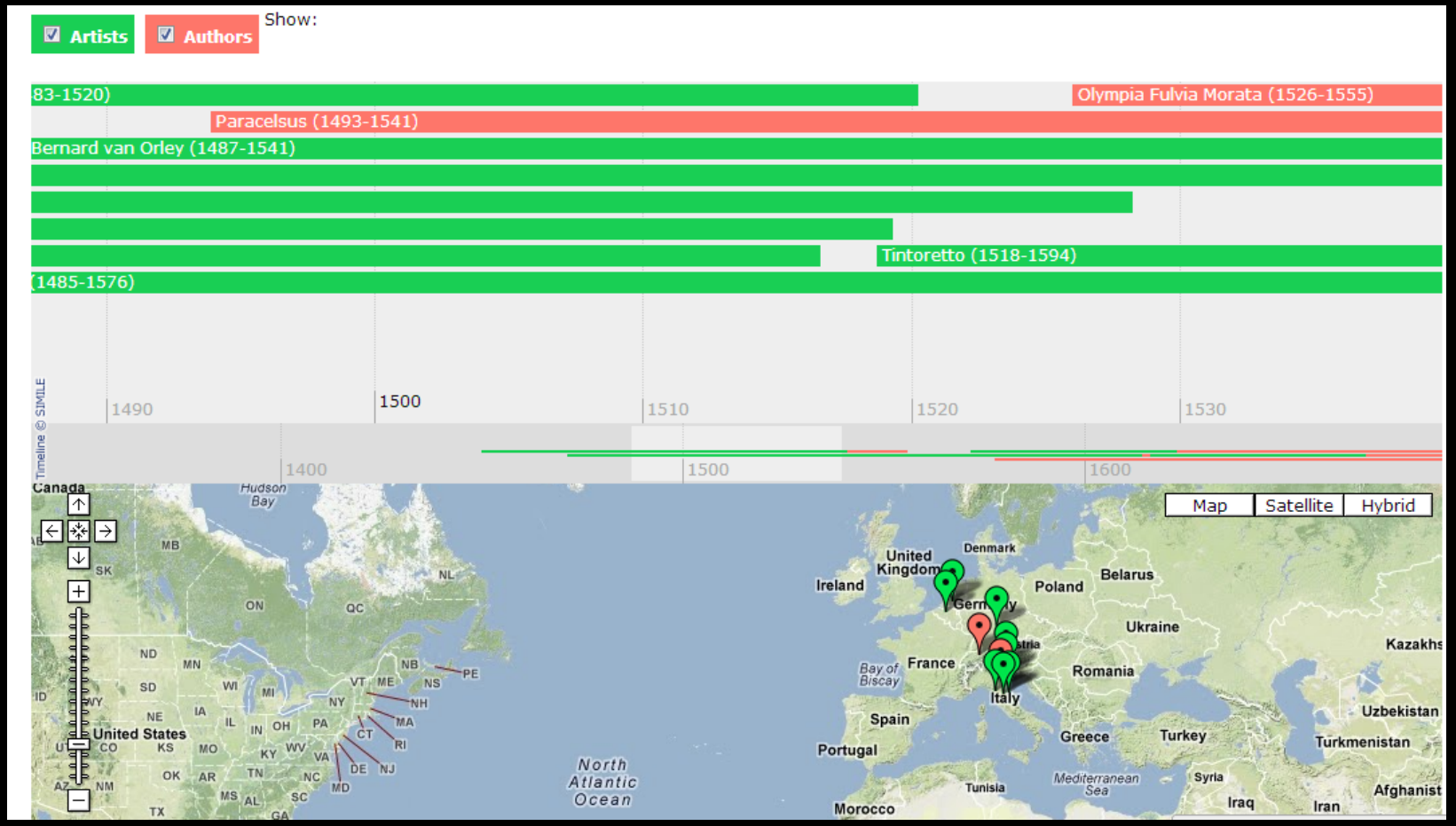
Proximity query (including temporal filter)

Temporal GIS visualizations - comparison within span of time



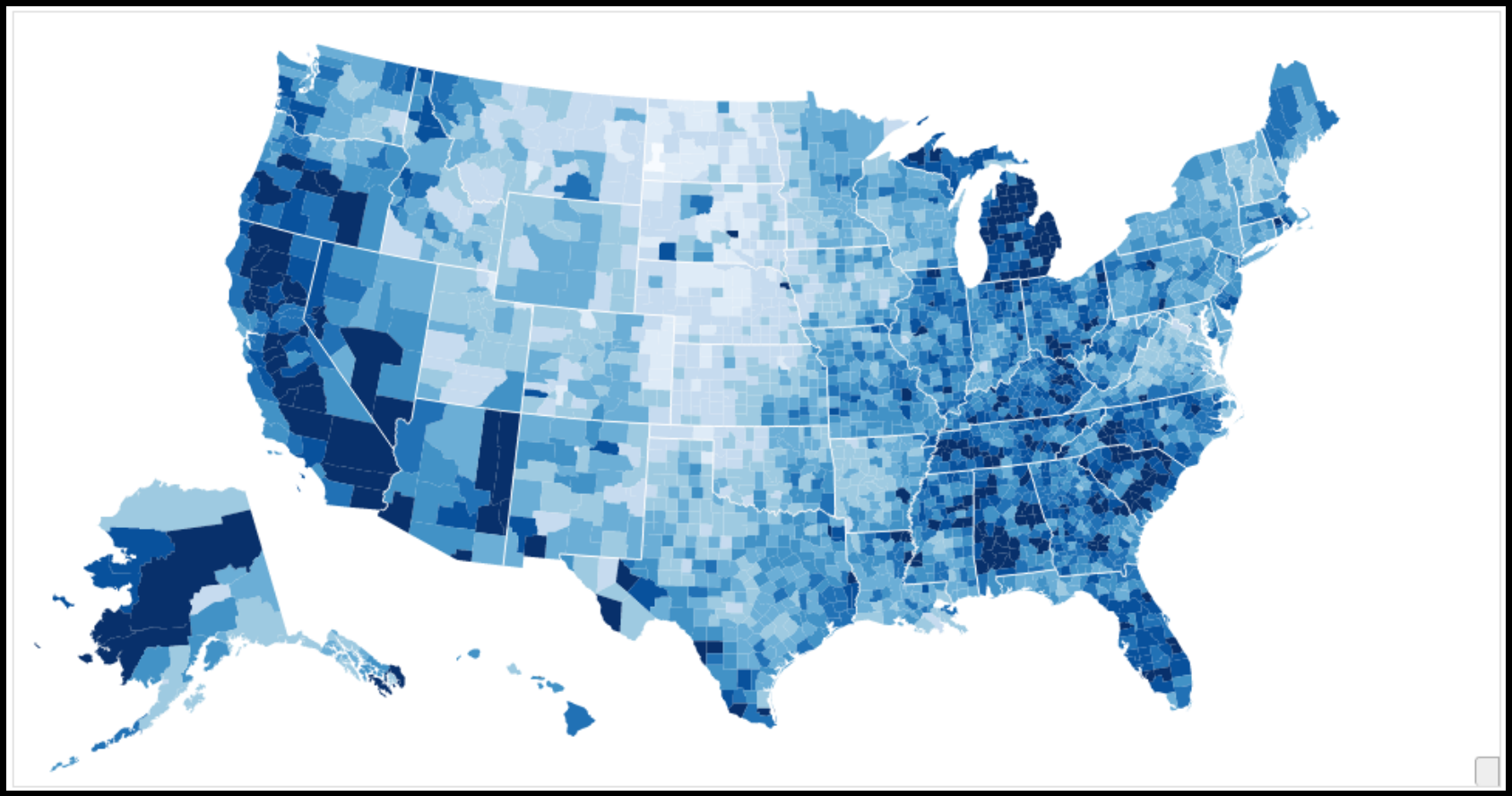
See: http://worldmap.harvard.edu/chinamap

Temporal GIS visualizations - combine timeline with map



See: https://code.google.com/p/timemap/

Temporal GIS visualizations - non-gis libraries



Unemployment rates 2008

See Michael Bostock D3 examples: https://github.com/mbostock/d3/wiki/Gallery

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+viz

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