Methods for Space-Time Analysis: Examples From the China Historical GIS

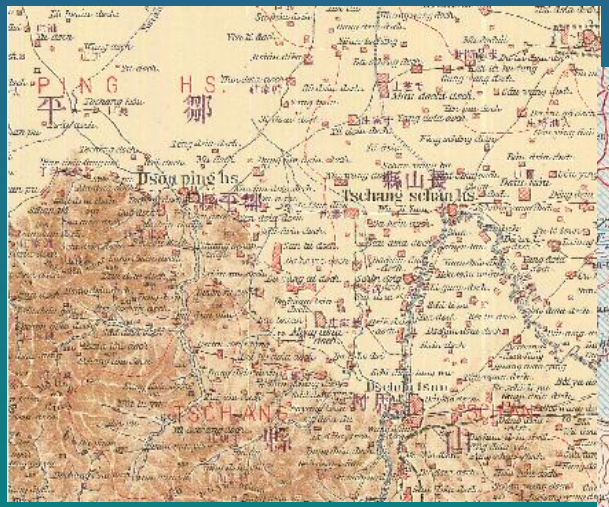
Mark Henderson
University of California, Berkeley

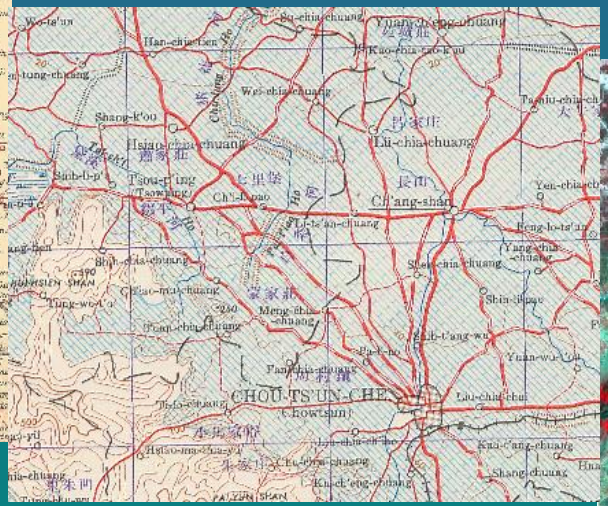
Merrick Berman
Harvard Yenching Institute

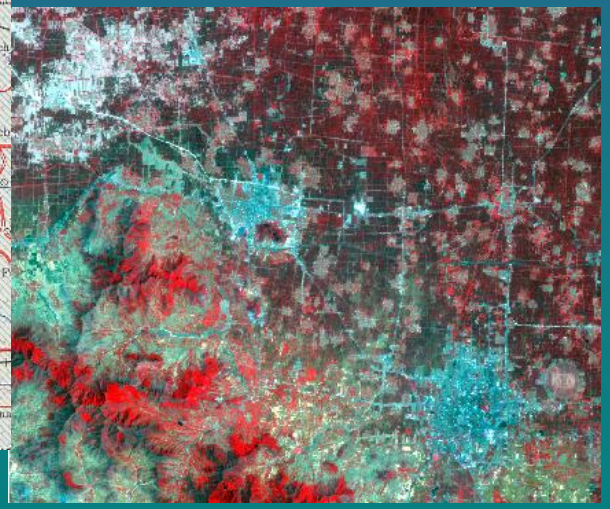
ESRI International User Conference, San Diego
July 9, 2003

Data Models for History in GIS

- History for historians or data managers?
- Arc/Info Coverage model or Geodatabase?
- Transactional model or Versioning?
- ESRI White Paper: “Modeling and Using History”

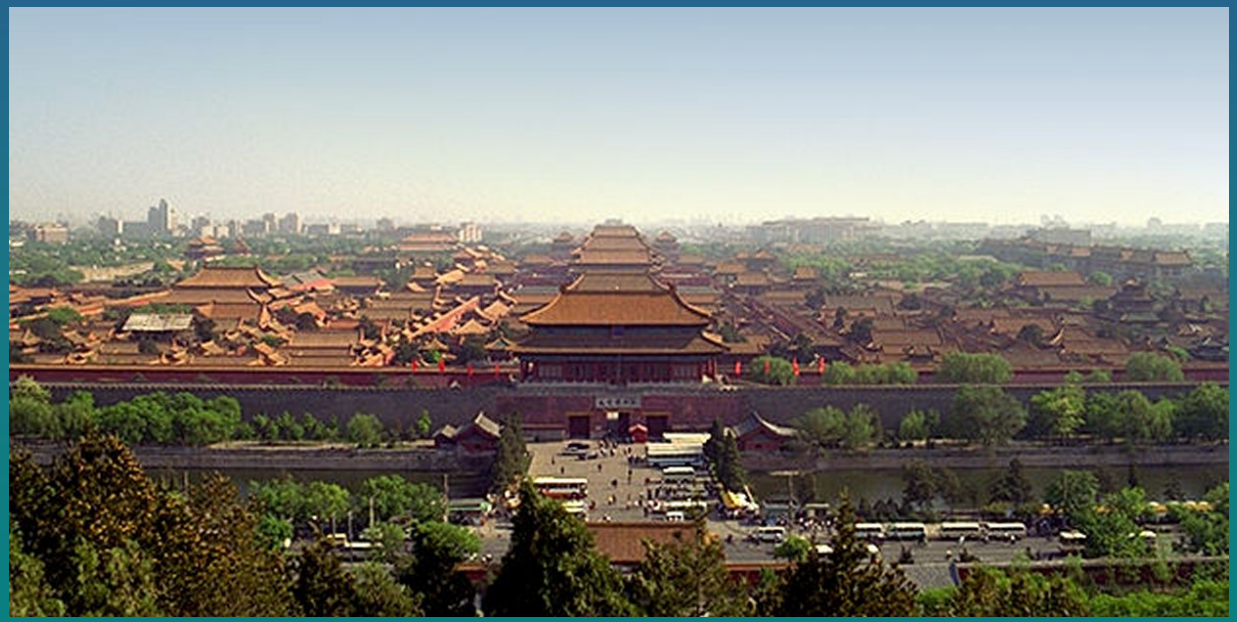






Chinese History: Why GIS?

- Historical continuity of records and county seats
- County gazeteers and memorials as data sources
- Position of counties in administrative hierarchy



The Chinese Historical GIS Project

Main project goals

- Create a database of historical administrative geography
- Provide a common framework for georeferencing historical materials
- Offer a GIS platform for spatio-temporal analysis

Other historical GIS projects:

- Great Britain Historical GIS
- US National Historical GIS
- TimeMap (University of Sydney)
- Electronic Cultural Atlas Initiative

Today's Topic: Data Models

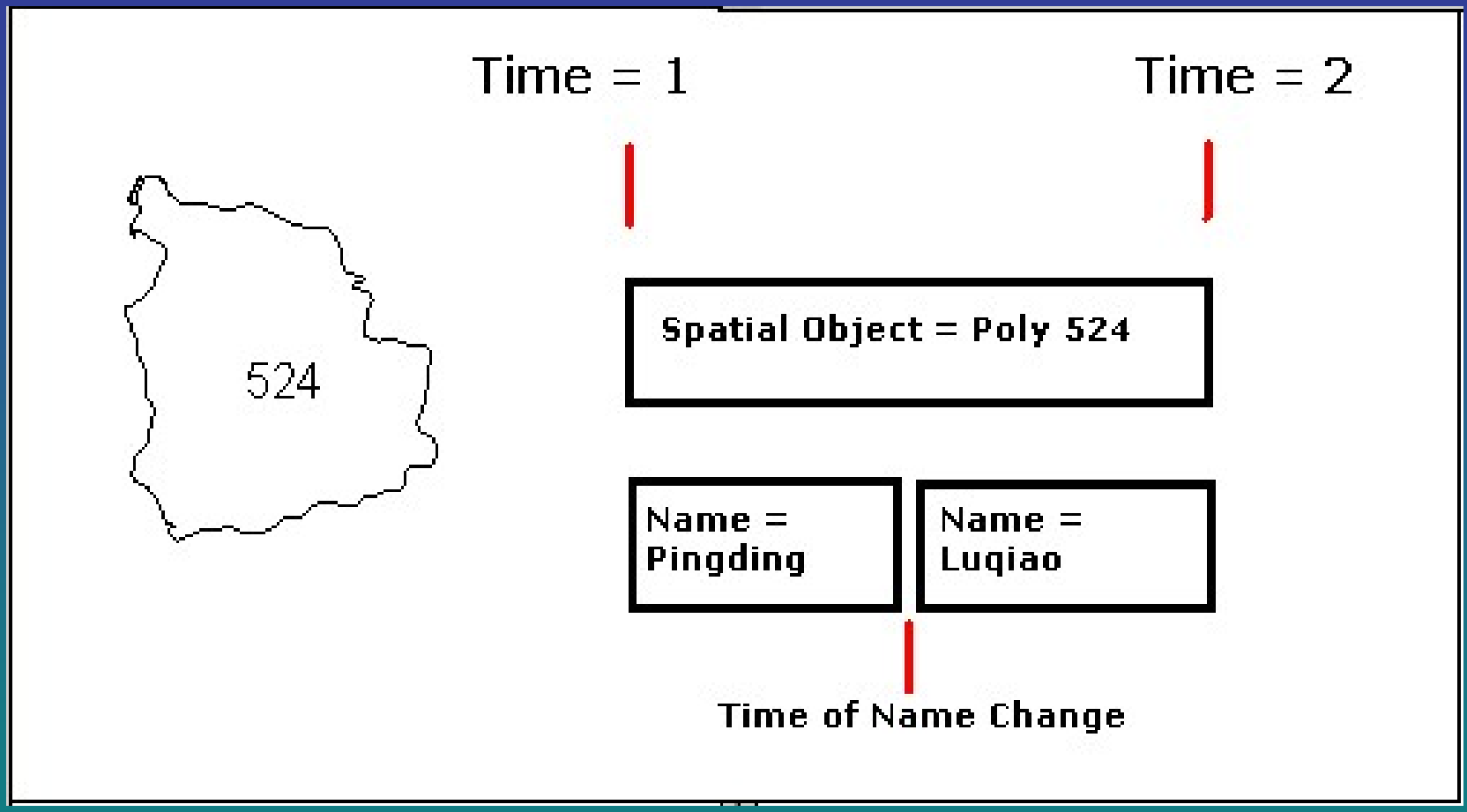
Three components

- Textual notes
- Digital map
- Data Tables
  - –Historical Instance Table

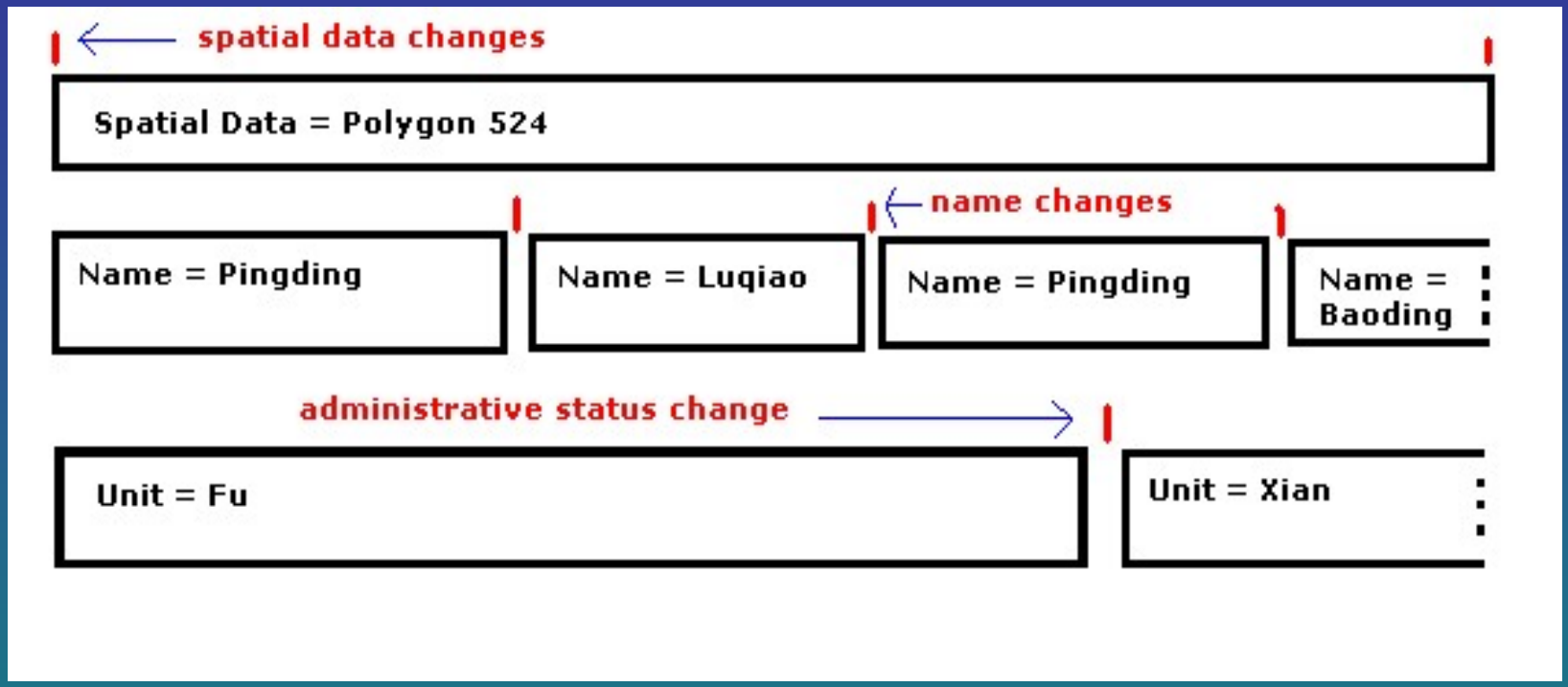
One “Historical Instance” has

- One place name
- One administative status
- One spatial object

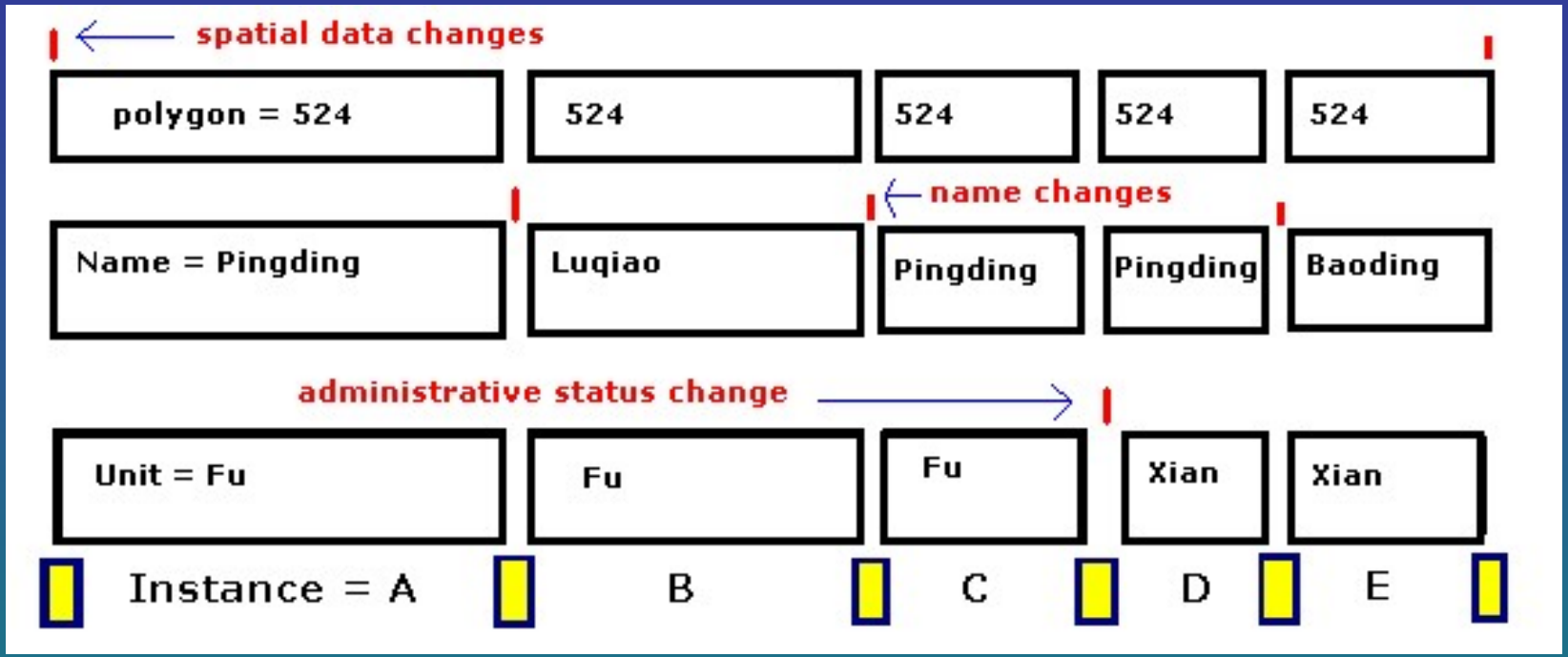
Name Change Makes Two Historical Instances



More Changes Make More Instances

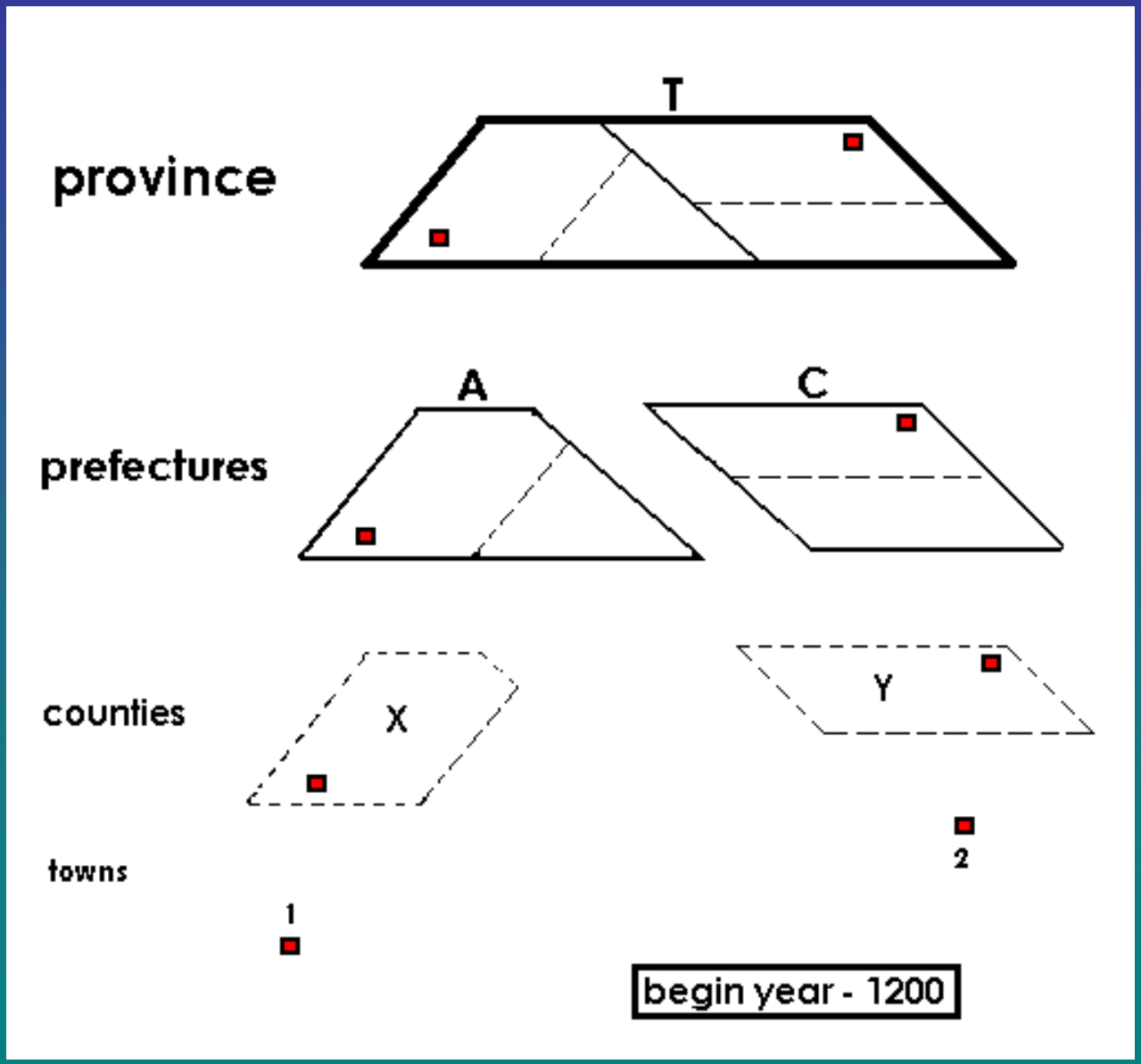


Attributes Unchanged Through Each Instance



Instance	Polygon	Name	Admin_Unit
A	524	Pingding	Fu
B	524	Luqiao	Fu
C	524	Pingding	Fu
D	524	Pingding	Xian
E	524	Baoding	Xian

Administrative Hierarchy



Historical Instances Table

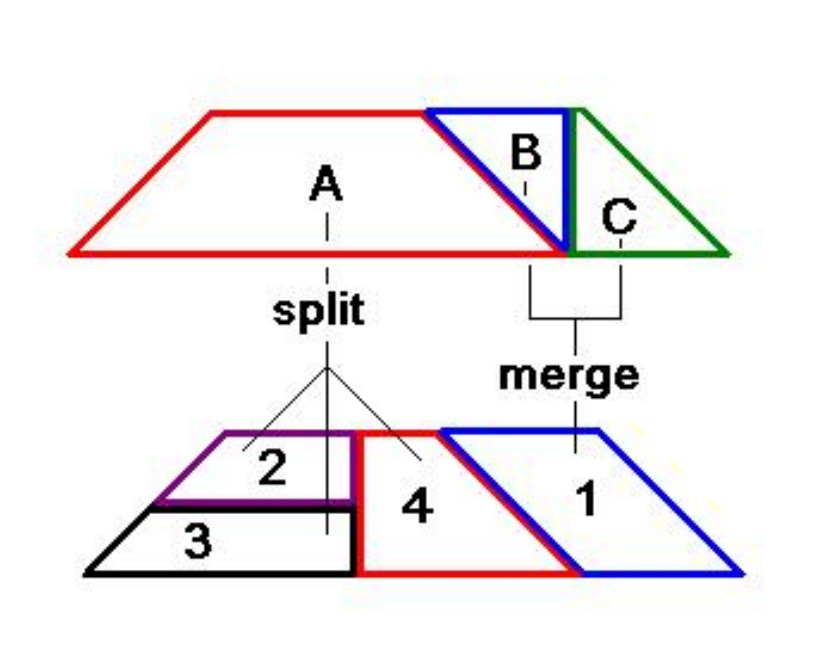
sys-id	hist-place	begin	end
333	Province T	1200	1350
334	Prefecture A	1200	1249
335	Prefecture B	1250	1350
336	Prefecture C	1200	1350
337	County X	800	1500
338	County Y	1200	1320
339	County Z	1321	1340
340	Town 1	200	1700
341	Town 2	100	1500

Temporal Sequence Table

sys-id	place-name	prec-by	prec-by-name
335	Prefecture B	334	Prefecture A
339	County Z	338	County Y

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



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

Suzhou from 1367 to 1990

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]。

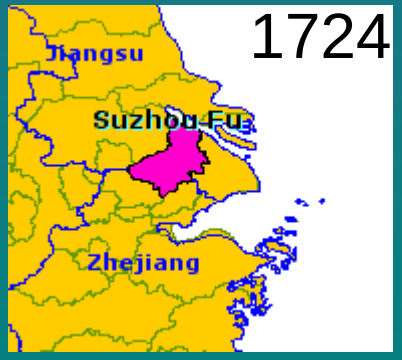
Tables

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)



Suzhou from 1367 to 1990

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]。

Suzhou from 1367 to 1990

Historical Instances Table

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

Temporal Sequence Table

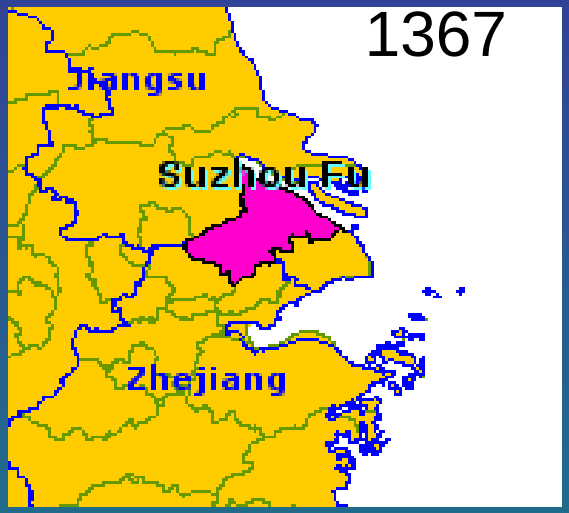
Sys-ID	Place-Name	Prec-ID	Prec-Name
90245	Suzhou Fu	90244	Suzhou Fu
90245	Suzhou Fu	40385	Chongming Zhou

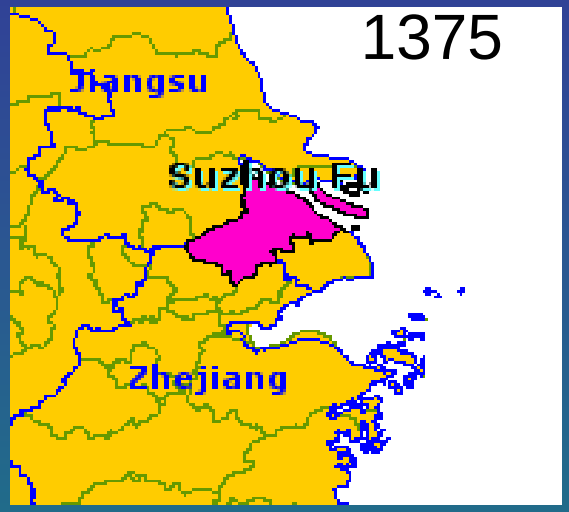
Part-Of Table

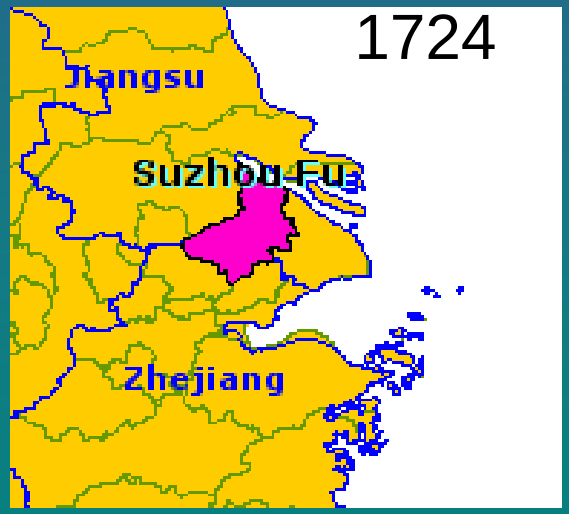
Sys-ID	Place-Name	Part-Of	From	To
90245	Suzhou Fu	Jiangnan Province	1645	1667
90245	Suzhou Fu	Jiangsu Province	1667	1911

Suzhou from 1367 to 1990

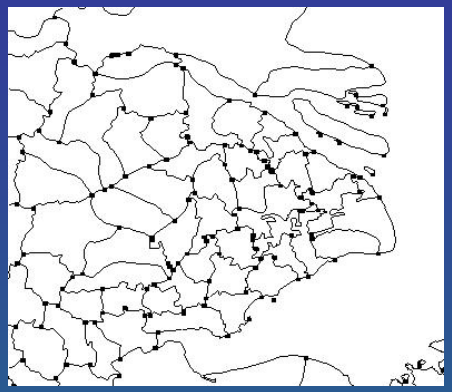
Spatial Objects (Regions)

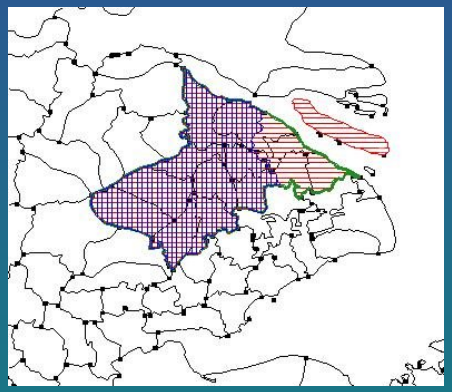


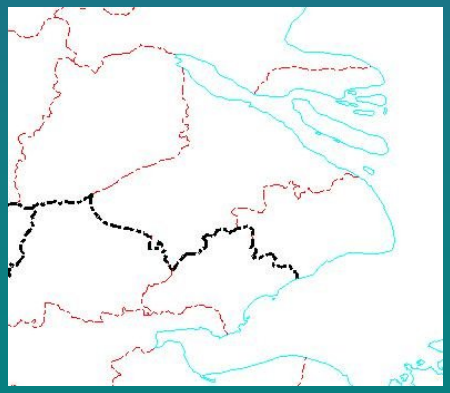




Generating Slices in Time



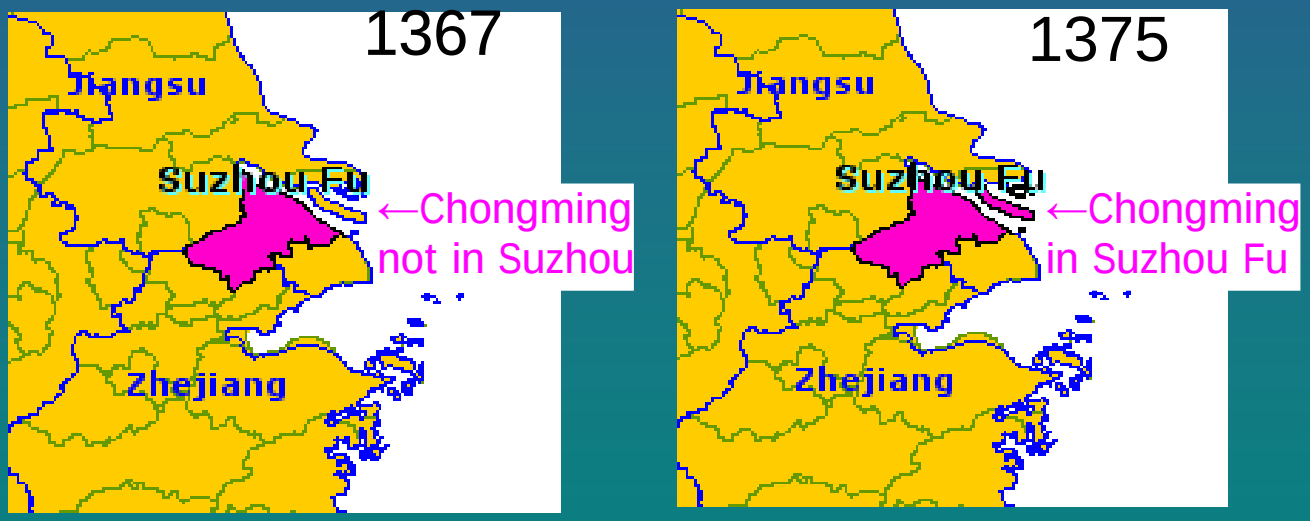




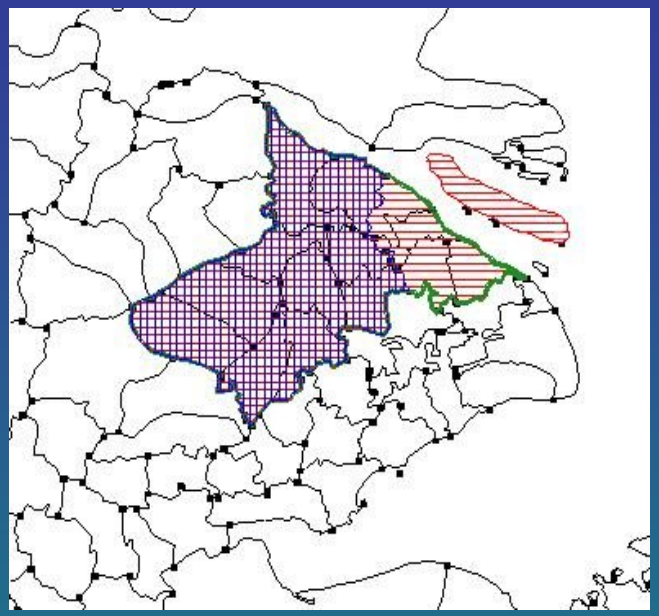
- "Atomic Polygons" with Regions for each historical instance
- Select Instances for a specific date
  - `Resel HistInst.dat start <= 1644 and ~ end >= 1644`
  - `Resel cov region.fu keyfile HistInst.dat ~ info fu# keyitem sys-id`
- Select Arcs associated with Regions
  - `Resel cov.PALfu info keyfile cov region.fu ~ unit keyitem fu#`
  - `Resel cov arc keyfile cov.PALfu info fu# ~ keyitem arc`
- Assign boundary symbols by comparing neighbors' parents
  - `Resel cov arc PALright//PartOfTable//part-of ~ <> PALleft//PartOfTable//part-of`
  - `Calc cov arc slice1644//btype = ~ slice1644//btype + 1`
  - `Arclines cov slice1644//btype ~ boundarysymbols.alut`

The Modifiable Areal Unit Problem (MAUP)

- Comparing areal units of different sizes in space
  - Aggregation effects
  - Scale effects
- MAUP compounded as units change through time
- Smallest Common Unit approach

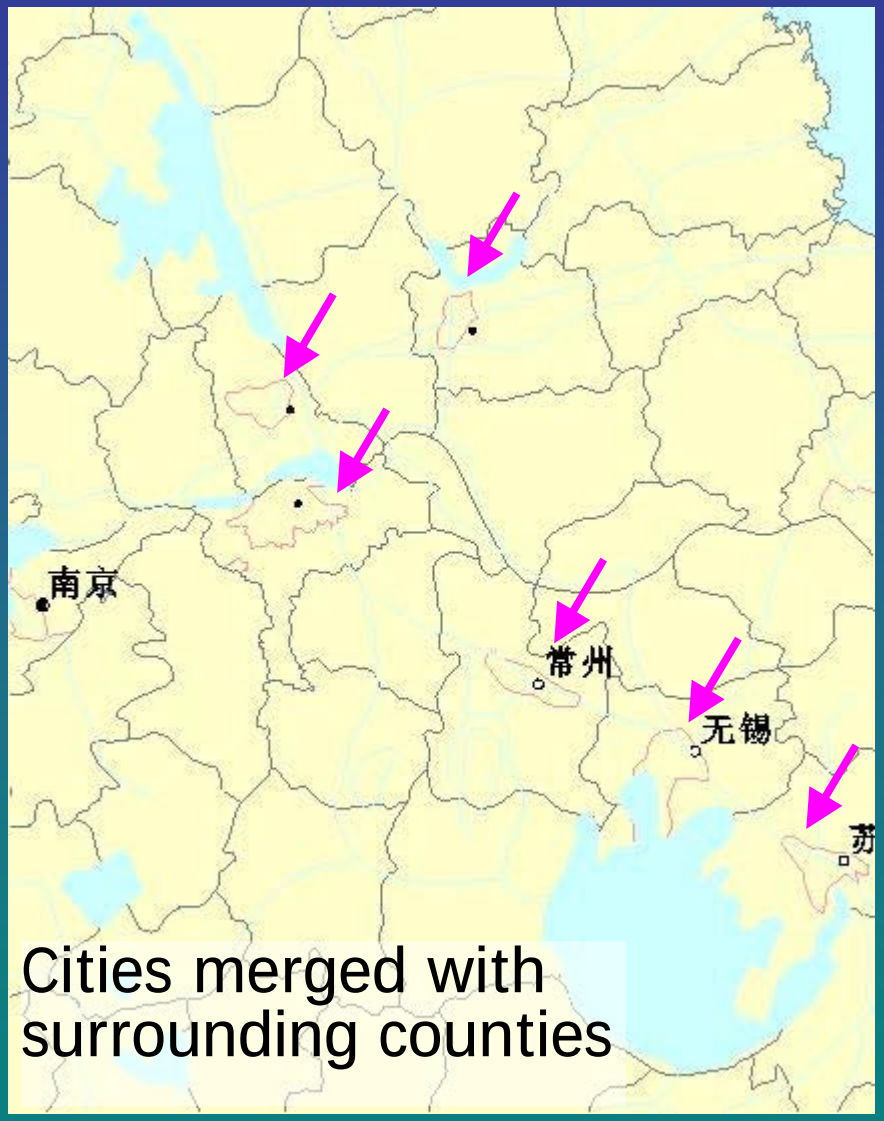


REGIONXAREA to Identify Smallest Common Units

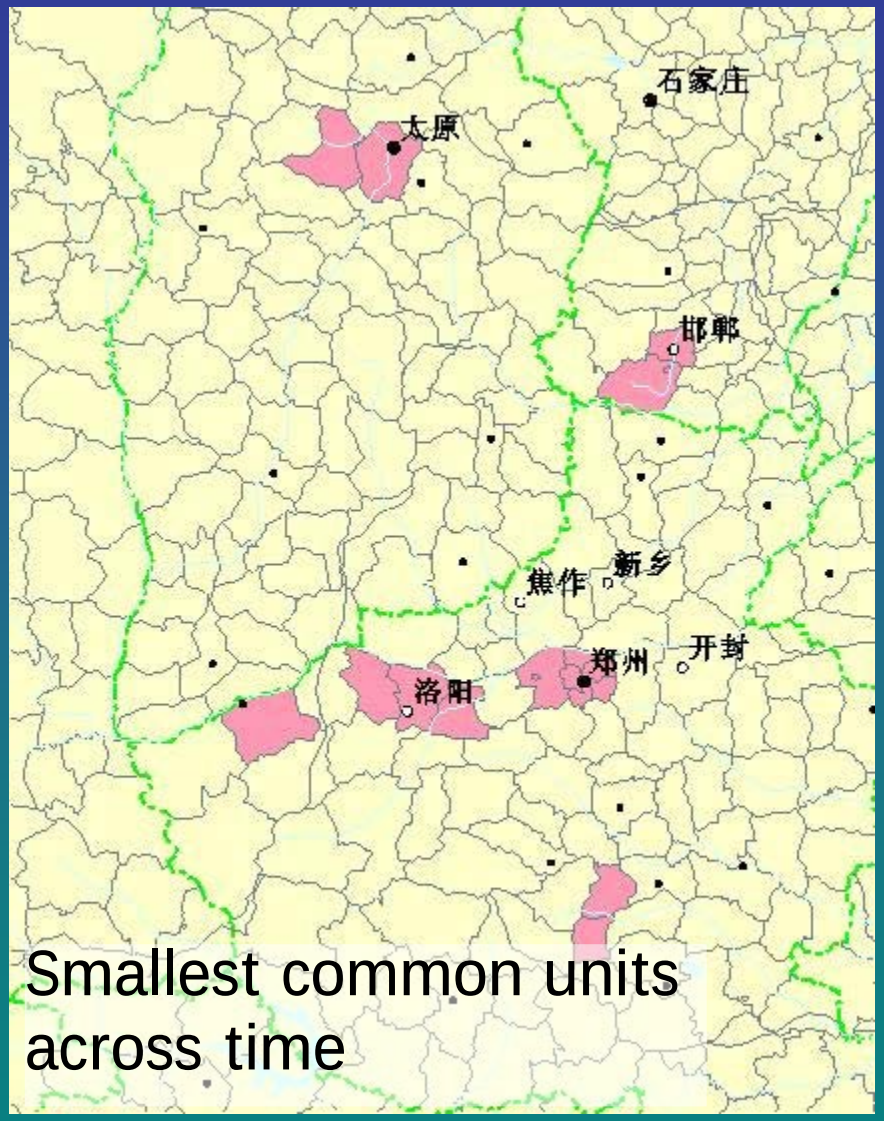


- XAREA table gives area and percentage of overlap between pairs of regions
- If overlap is not 100%, iteratively merge other regions that overlap
- Calculate statistics for Smallest Common Unit

The MAUP and Analytical Mergers

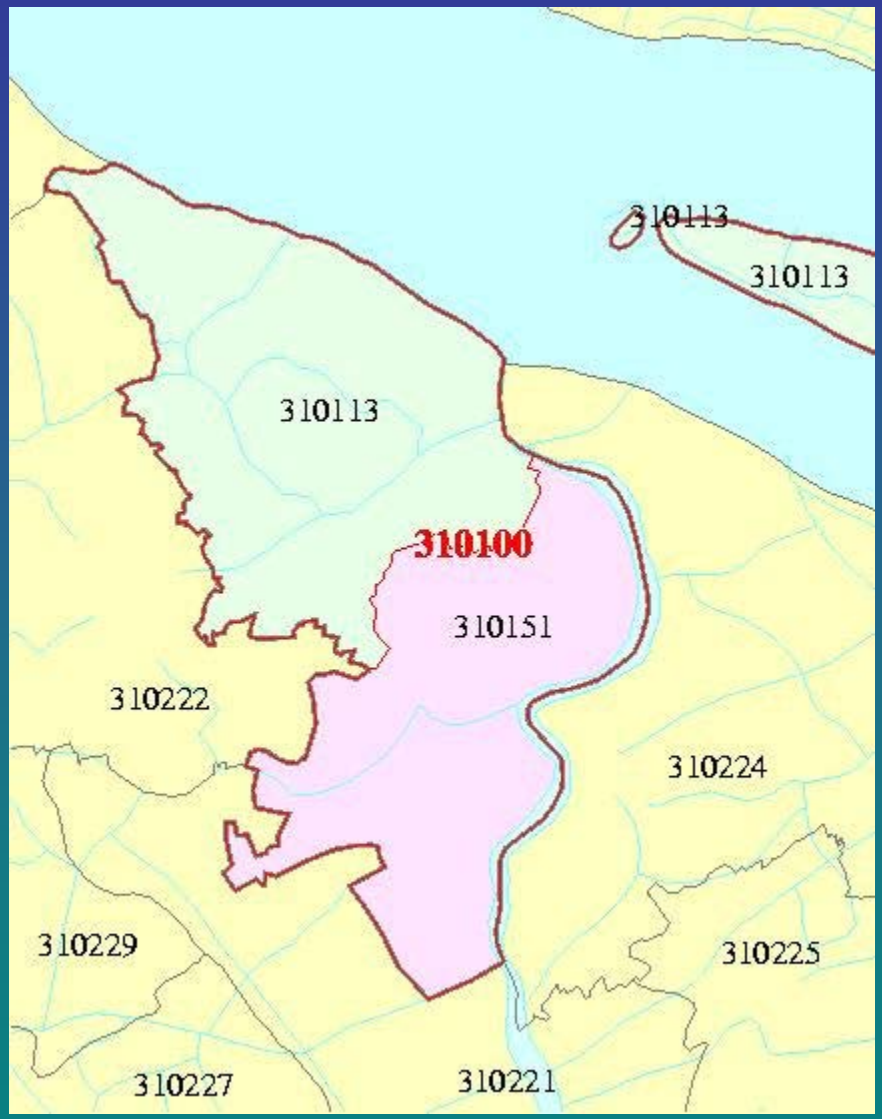


Cities merged with surrounding counties

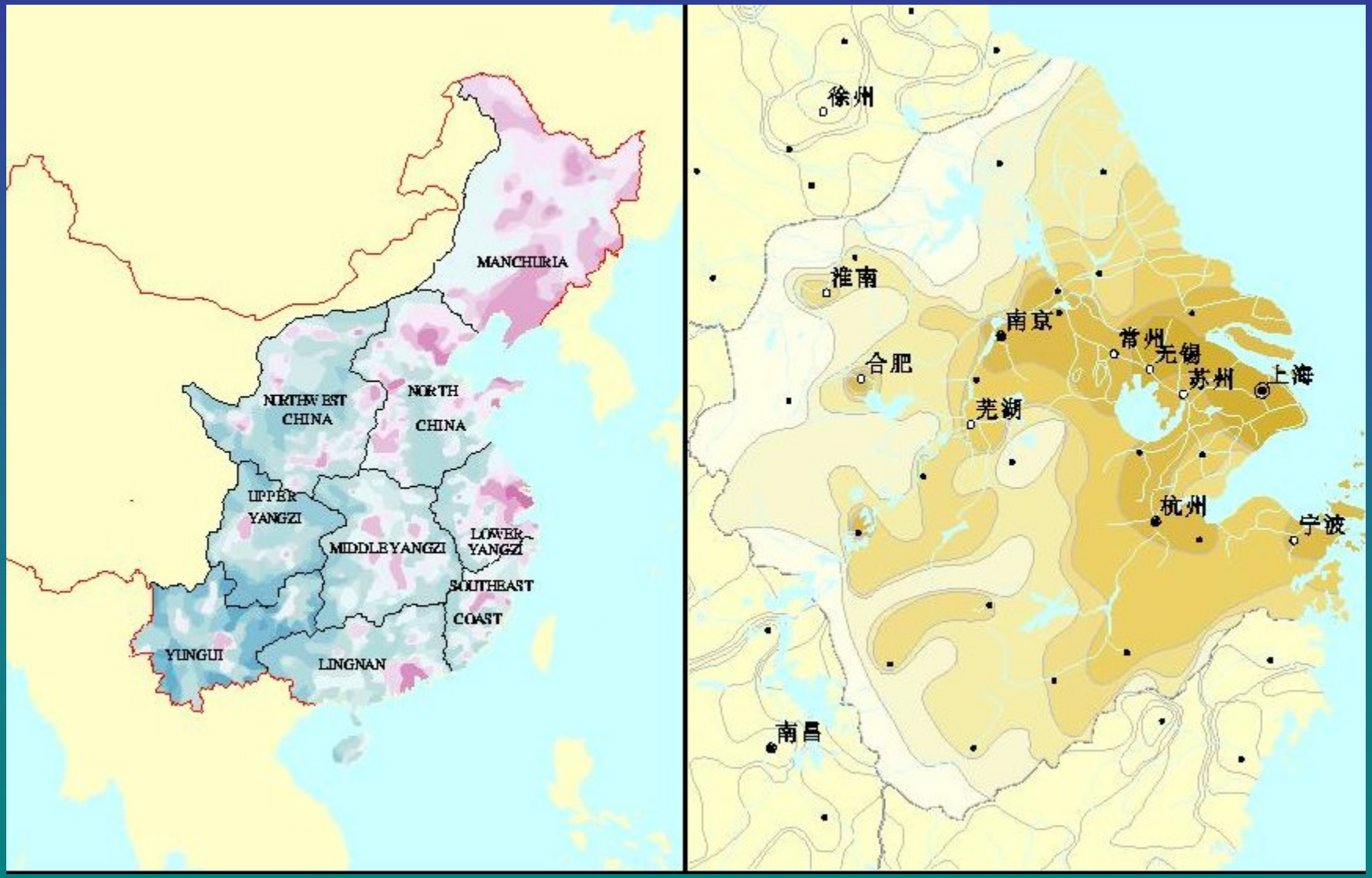


Smallest common units across time

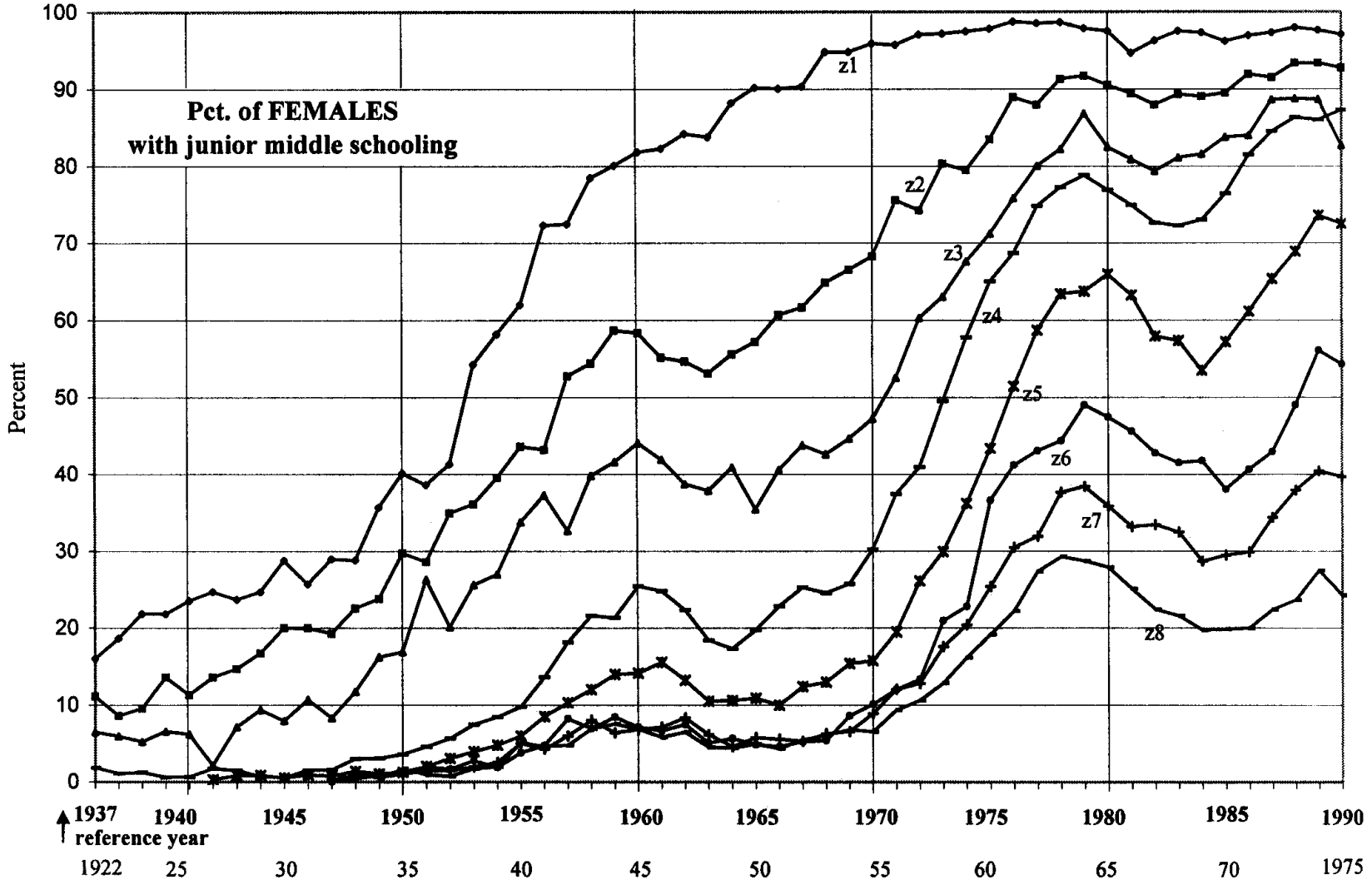
Analytical Mergers: Shanghai



The Spatial Approach to Chinese History



Space-time analysis of junior middle schooling, FEMALES only:
data by year of birth, 1922-1975
(and reference year, 15 years later, 1937-1990)
and by HRS zone, Lower Yangzi macroregion



Methods for Space-Time Analysis: Examples From the China Historical GIS

www.fas.harvard.edu/~chgis

Thanks to:
Ge Jianxiong and Man Zhimin, Fudan University
G. William Skinner, UC Davis
Lawrence Crissman, Griffith University
ESPM Division of Forest Science and
Geographic Information Science Center, UC Berkeley