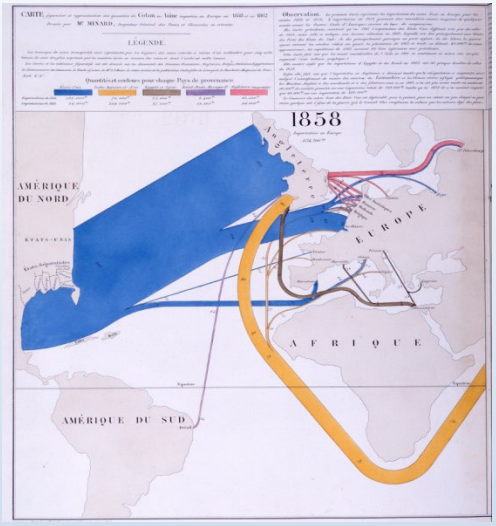
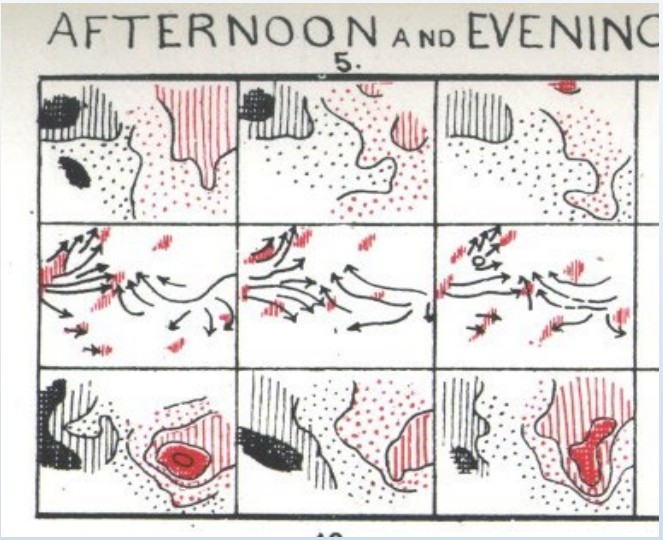
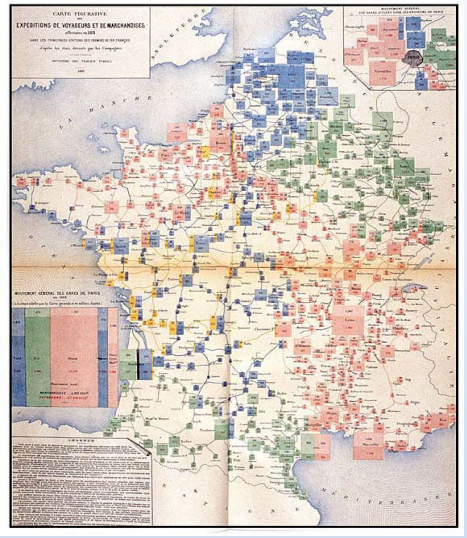






The Golden Age of Statistical Graphics

Michael Friendly

Psych 6135

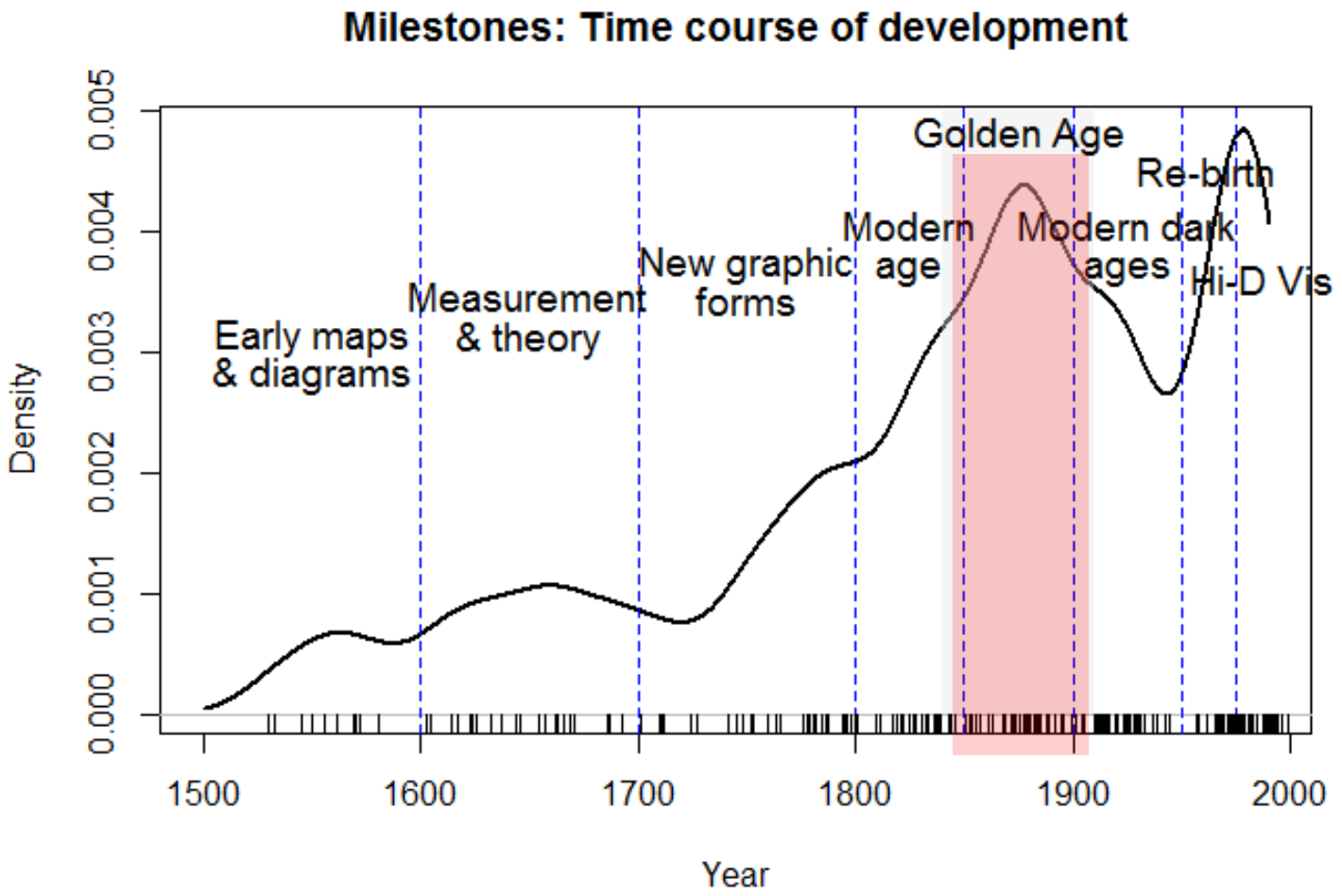
https://friendly.github.io/6135

#psy6135 Psychology of Data Visualization

#psy6135 Psychology of Data Visualization

The Golden Age: ~ 1850 -- 1900

Why do I call this the “Golden Age of Statistical Graphics”?
The most obvious is as a peak in developments over the course of history.



What makes an “Age”?
What makes one “Golden”?

- Age:
  - Qualitatively distinct from before & after
- Golden age:
  - Recognizable period in a field where great tasks were accomplished
  - Years following some innovations
  - Artists apply skills to new areas
  - New ideas expressed, art forms flourish
  - Often ends with some turning point event(s)

Some Golden Ages

- **Athens** (Pericles): 448 BC—404 BC: growth & culture
- **Islam**: 750—1258 (sack of Baghdad): science, math …
- **England**: Elizabeth I (1558-1603): literature, poetry, …
- **Piracy**: 1690--1730
- **Radio**: 1920—1940
- **Animation**: 1928 (sound) – 1960s (TV)
- **Senior citizens**: 60+

Metaphors

Pietro Da Cortona, *The Golden Age* (Fresco, Sala della Stufa, Palazzo Pitti, Florence)

Preludes to the Golden Age

Infrastructure required:

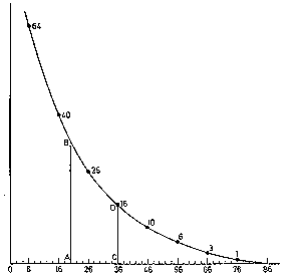
- **Data**: collection & dissemination
- **Statistical theory**: combining & summarizing quantitative information
- **Technology**: printing & reproduction of maps & diagrams
- **Visual language**: new graphic forms for maps and diagrams
- → a perfect storm for data graphics

What does this imply for today?

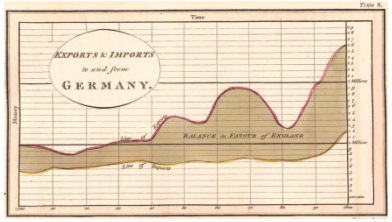
Preludes: data

"Data! Data! I can't make bricks without clay." – **Sherlock Holmes, *Copper Beeches***

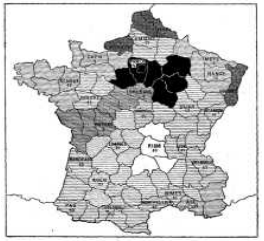
- Population: ~ 1660--
  - Bills of mortality: Graunt (1662)
  - Political arithmetic: Petty (1665)
  - Demography: Süssmilch (1741)



- Economic data: ~ 1770--
  - Revenue, expenditures, taxes
  - Imports, exports
  - Transport

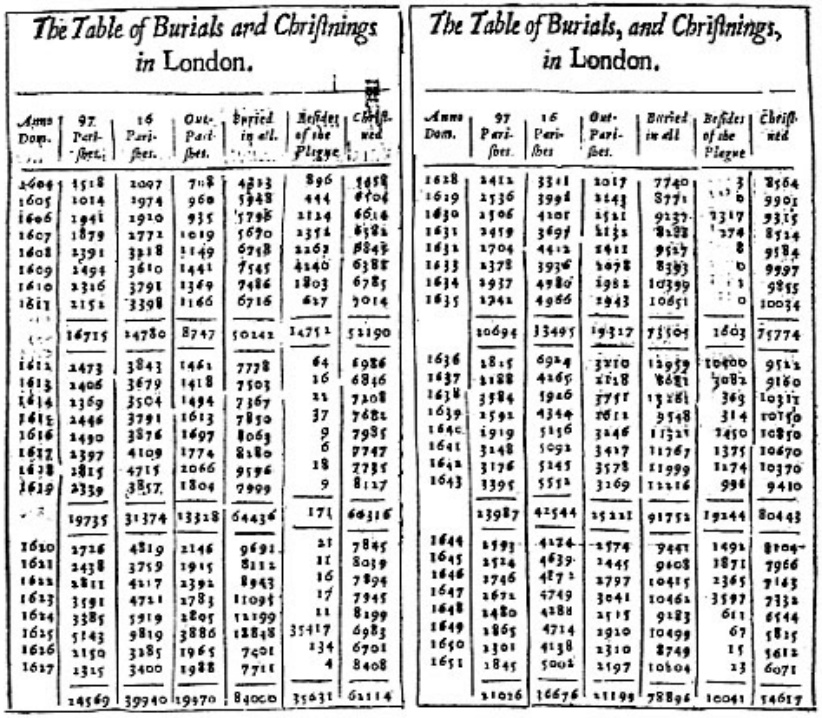


- Social data: ~ 1820--
  - Literacy, education
  - Crime, suicides, illegitimate births, prostitution
  - Poverty, debtors, disease



- → An avalanche of data, waiting to be visualized!

Population data: keeping track of births, deaths, causes of mortality



The Table of Burials and Christnings in London.

Anno Dom.	97 Parishes.	16 Parishes.	Out-Parishes.	Buried in all.	Besides of the Plague	Christned
1604	1518	2007	718	4243	896	3858
1605	1014	1974	960	3948	444	4704
1606	1941	2910	935	5798	2124	6616
1607	1879	2772	1019	5670	2354	6582
1608	2391	3318	1149	6758	2262	8843
1609	1494	3610	1441	7545	4440	6388
1610	2316	3791	1369	7486	1803	6785
1611	2152	3398	1166	6716	617	7014
	16715	24780	8747	50242	14752	52190
1612	2473	3843	1461	7778	64	6986
1613	2406	3679	1418	7503	16	6846
1614	2369	3504	1494	7367	21	7208
1615	2446	3791	1613	7850	37	7682
1616	2490	3876	1697	8063	9	7985
1617	2397	4109	1774	8280	6	7747
1618	2815	4715	2066	9596	18	7735
1619	2339	3857	1804	7999	9	8127
	19735	31374	13328	64436	171	60316
1620	2726	4819	2146	9691	21	7845
1621	2438	3759	1915	8112	11	8039
1622	2811	4817	2392	8943	16	7894
1623	3591	4721	2783	11095	17	7945
1624	3385	5319	2805	12199	11	8199
1625	5143	9819	3886	18848	35417	6983
1626	2150	3385	1965	7401	134	6701
1627	2315	3400	1988	7711	4	8408
	24569	39940	19570	84000	35631	61114

The Table of Burials, and Christnings, in London.

Anno Dom.	97 Parishes.	16 Parishes.	Out-Parishes.	Buried in all	Besides of the Plague	Christned
1628	2412	3311	2017	7740	3	8564
1629	2536	3992	2143	8771	6	9901
1630	2506	4101	2521	9237	3317	9315
1631	2459	3697	2132	8288	374	8514
1632	2704	4412	2411	9527	8	9184
1633	2378	3936	2078	8393	0	9997
1634	2937	4980	2952	10399	1	9855
1635	2741	4966	2943	10651	0	10034
	20694	33495	19317	75505	1603	75774
1636	2815	6924	3210	13959	10400	9522
1637	2188	4265	2118	8681	3082	9180
1638	3584	5926	3751	13281	363	10317
1639	2592	4344	2611	9548	314	10150
1640	1919	5156	3246	11321	2450	10850
1641	3148	5052	3417	11767	1375	10670
1642	3176	5145	3578	11999	1174	10370
1643	3395	5512	3269	12216	996	9410
	23987	42544	25221	91752	19244	80443
1644	1593	4124	2574	9441	1491	8104
1645	2524	4639	2445	9108	1871	7966
1646	2746	4873	2797	10415	2365	7163
1647	2672	4749	3041	10462	3597	7332
1648	2480	4288	2515	9283	611	6544
1649	1865	4714	2910	10499	67	5815
1650	2301	4138	2310	8749	15	5612
1651	1845	5002	2197	10804	23	6071
	21016	36676	21199	78896	10041	54617

J. Graunt (1662) *Natural and Political Observations on the Bills of Mortality*

1665.

A General BILL for this present Year,

Ending the 19th Day of December 1665.

According to the Report made to the King's most excellent Majesty,

By the Company of Parish Clerks of LONDON, &c.

DISEASES and CASUALTIES.

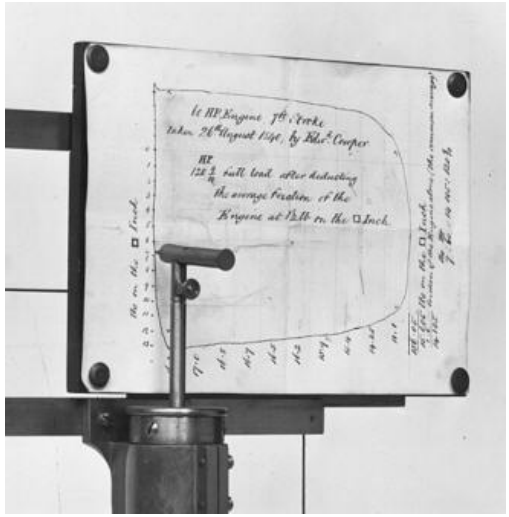
Abortive and Stillborn	617	Executed	21	Overlaid and Starved	45
Aged	1545	Flox and Small Pox	655	Palsy	30
Ague and Fever	5257	Found dead in the Streets, Fields, &c.	23	Plague	68596
Apoplexy and Suddenly	116	French Pox	86	Planet	6
Bedrid	10	Frighted	23	Plurisy	15
Blasted	5	Gout and Sciatica	27	Poisoned	1
Bleeding	16	Grief	46	Quinsy	35
Bloody Flux, Scowring, and Flux.	185	Griping in the Guts	1288	Rickets	557
Burnt and Scalded	8	Hang'd and made away themselves	7	Rising of the Lights	397
Calenture	3	Headmouldshot and Mouldfallen	14	Rupture	34
Cancer, Gangrene, and Fistula	56	Jaundies	110	Scurvy	105
Canker and Thrush	111	Imposthume	227	Shingles and Swine Pox	2
Childbed	625	Kill'd by several Accidents	46	Sores, Ulcers, broken and bruised Limbs	82
Chrisomes and Infants	1258	King's Evil	86	Spleen	14
Cold and Cough	68	Leprosy	2	Spotted Fever and Purples	1929
Colick and Wind	134	Lethargy	14	Stopping of the Stomach	332
Consumption and Tissick	4808	Livergrown	20	Stone and Strangury	98
Convulsion and Mother	2036	Megrims and Head-ach	12	Surfeit	1251
Distracted	5	Measles	7	Teeth and Worms	2614
Dropsy and Tympany	1478	Murdered and Shot	9	Vomiting	51
Drowned	50			Wen	1

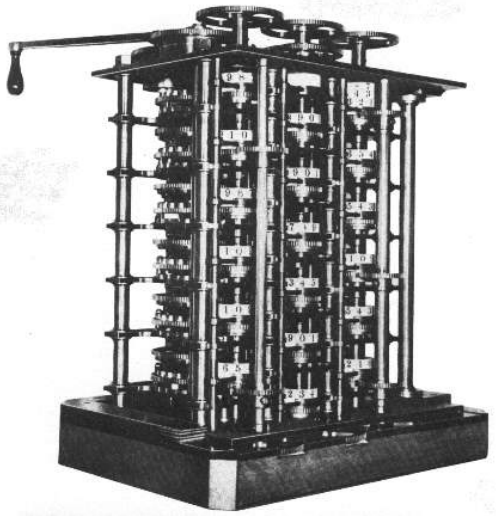
CHRISTENED { Males — 5114, Females 4853, In all — 9967 } BURIED { Males — 48569, Females 48737, In all — 97306 } Of the Plague 68596

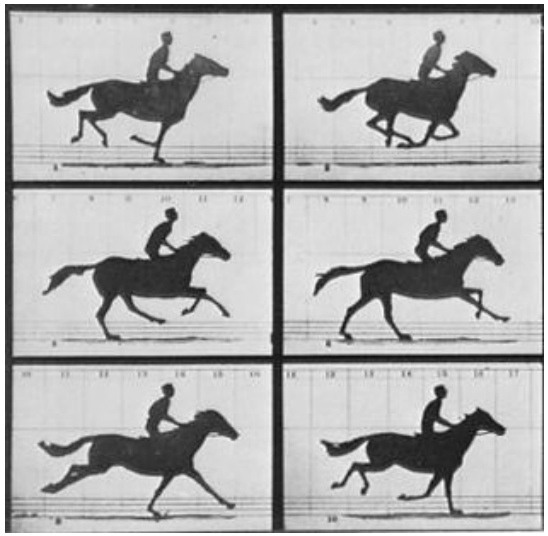
Increased in the Burials in the 130 Parishes and at the Pest-house this Year 79009
Increased of the Plague in the 130 Parishes and at the Pest-house this Year 68590

Preludes: technology

- Copperplate → Lithography (1800+) → color printing (1850+)
- Automatic recording: James Watt (1822)
- Calculation: Babbage (1822/33), Guerry ~1850
- Photography: Niépce (1827), Deguerre (1839), trichromatic process (1861)
- Motion: Muybridge (1872), Marey (1882)

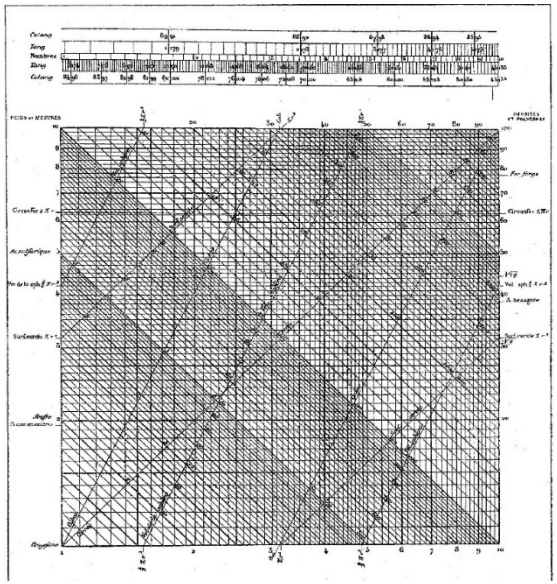


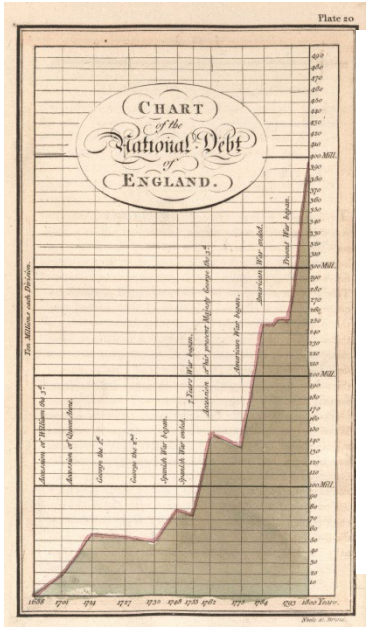


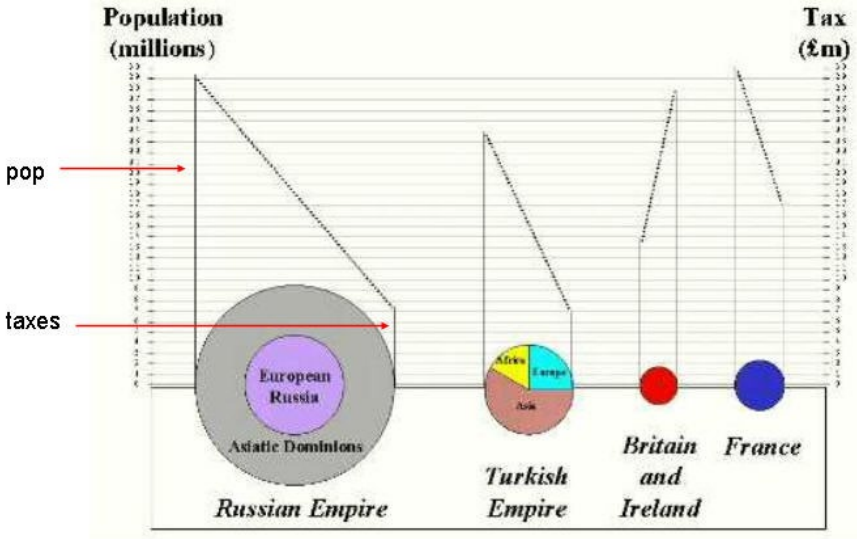


Preludes: visual language

- Graphs & diagrams
  - Line, bar, pie charts– Playfair (1786, 1801)
  - Scatterplot– Herschel (1832)
  - Polar plots– Guerry (1829), Nightingale (1857)
  - Nomograms & graphical calculation– Lalanne (1846)

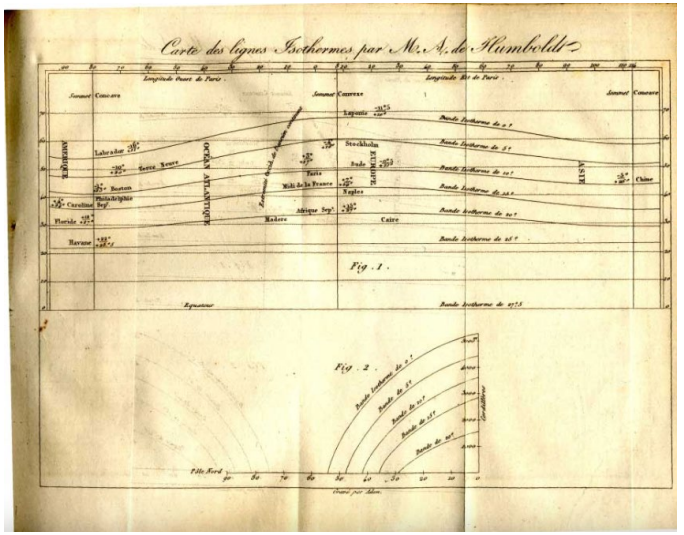


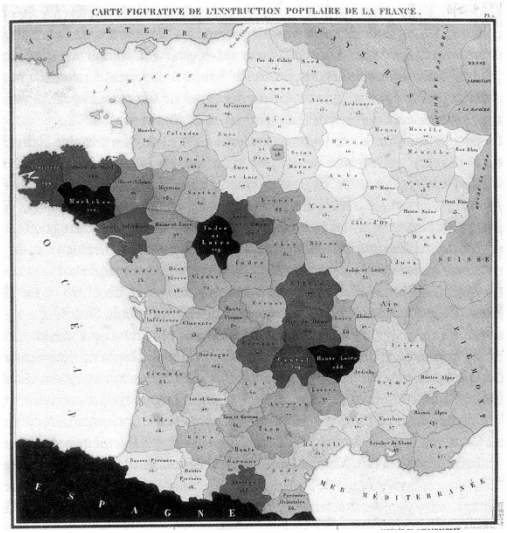


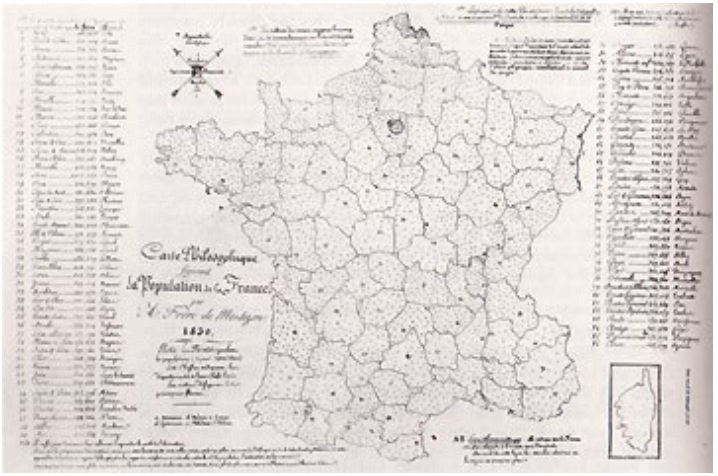


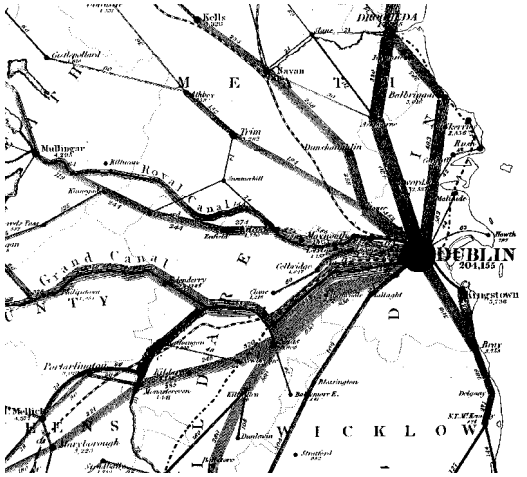
Preludes: visual language

- Thematic maps
  - Isopleth– Humboldt (1817)
  - Choropleth– Dupin (1826)
  - Dot– Frère de Montizon (1830)
  - Flow– Harness (1837)





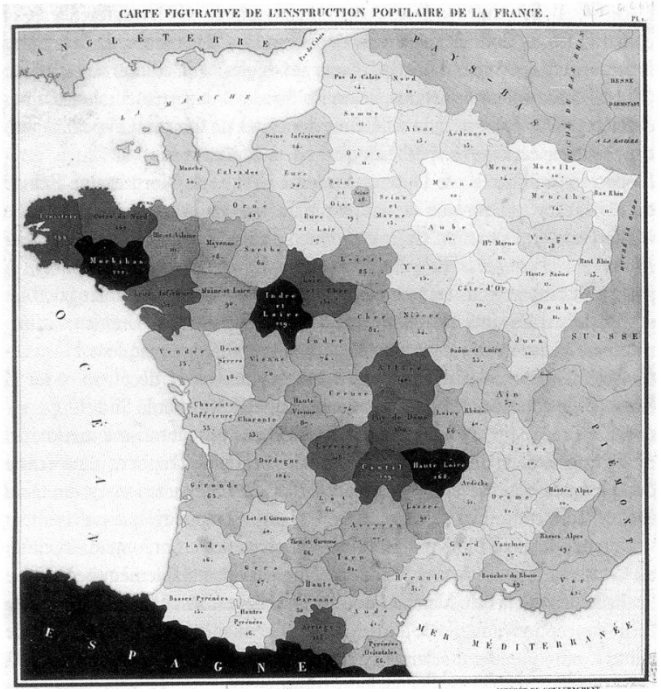




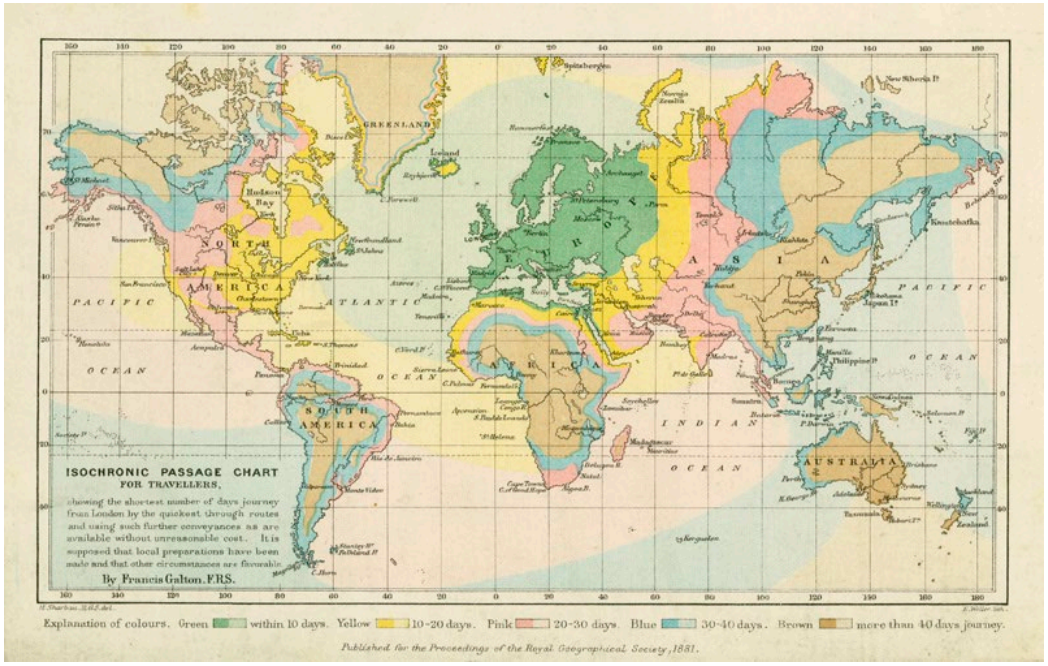
Data visualization: Diffusion of ideas

- Those who developed thematic maps often not cartographers

Dupin (1826): literacy in France

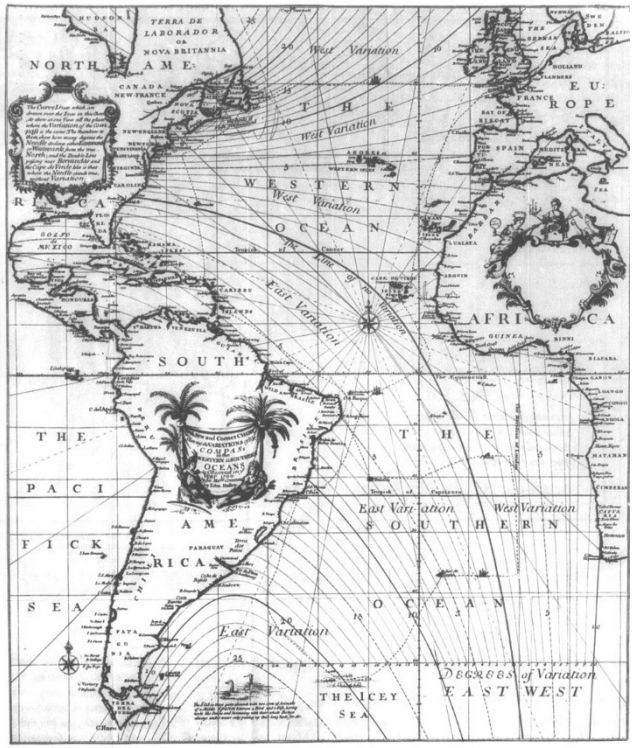


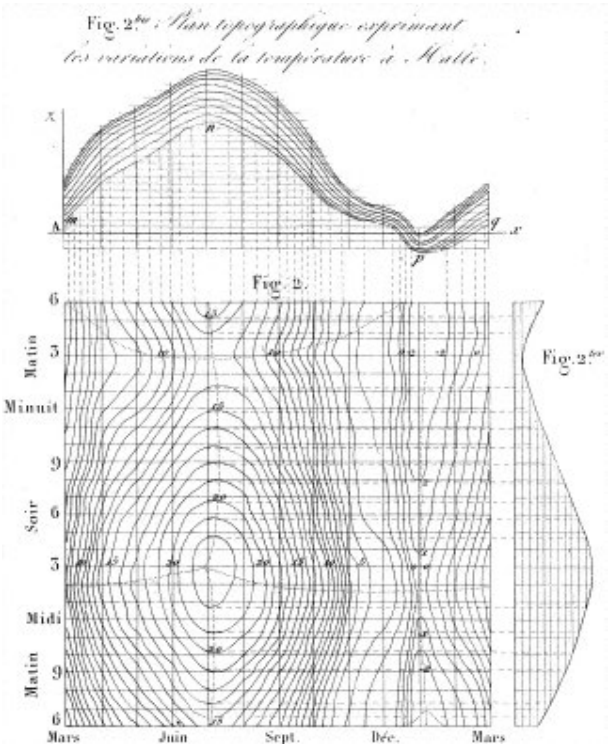
Galton (1881): travel time from London



Data visualization: Diffusion of ideas

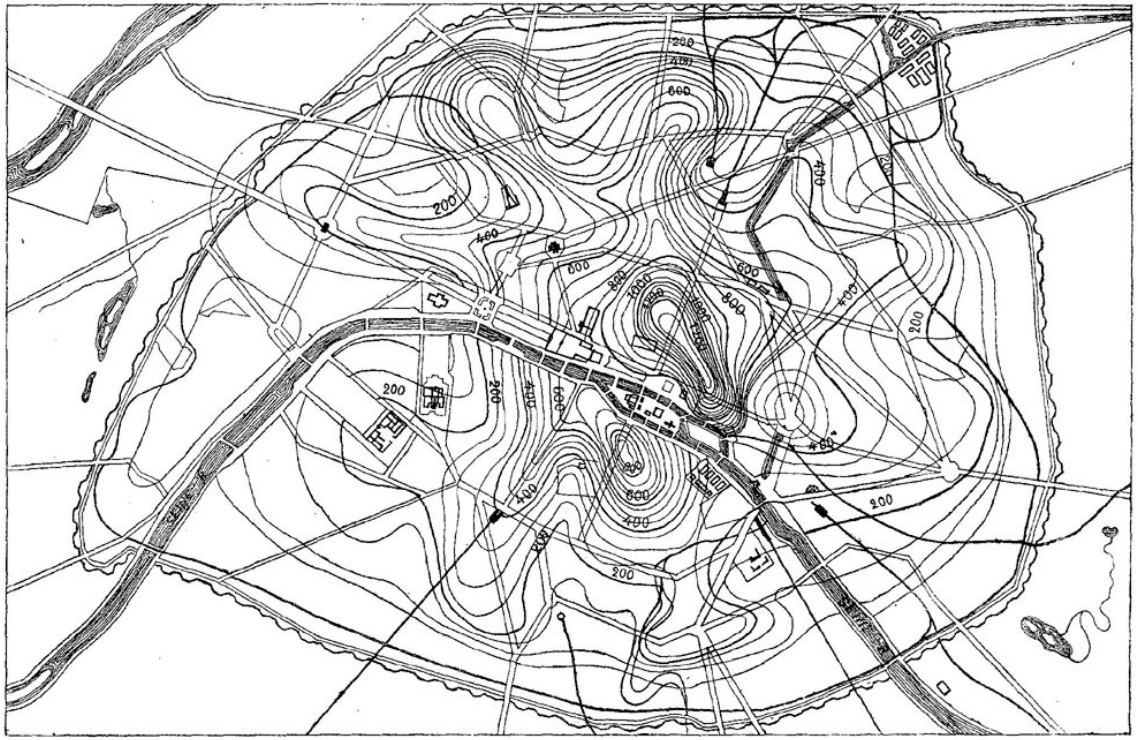
- Those who developed data graphics often borrowed from cartography
  - Halley (1701): contour map -> Lalanne (1843): contour diagrams of soil temperature





Data visualization: Diffusion of ideas

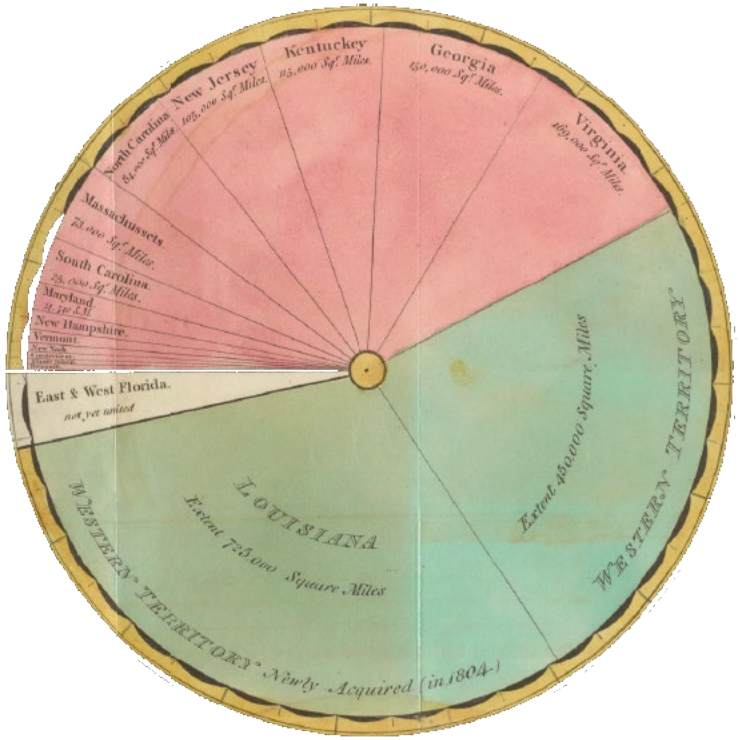
- … and vice-versa
  - Lalanne → L.L. Vauthier (1874) contour map of population density of Paris, seen as mountains
  - Map-based data visualization was extended widely



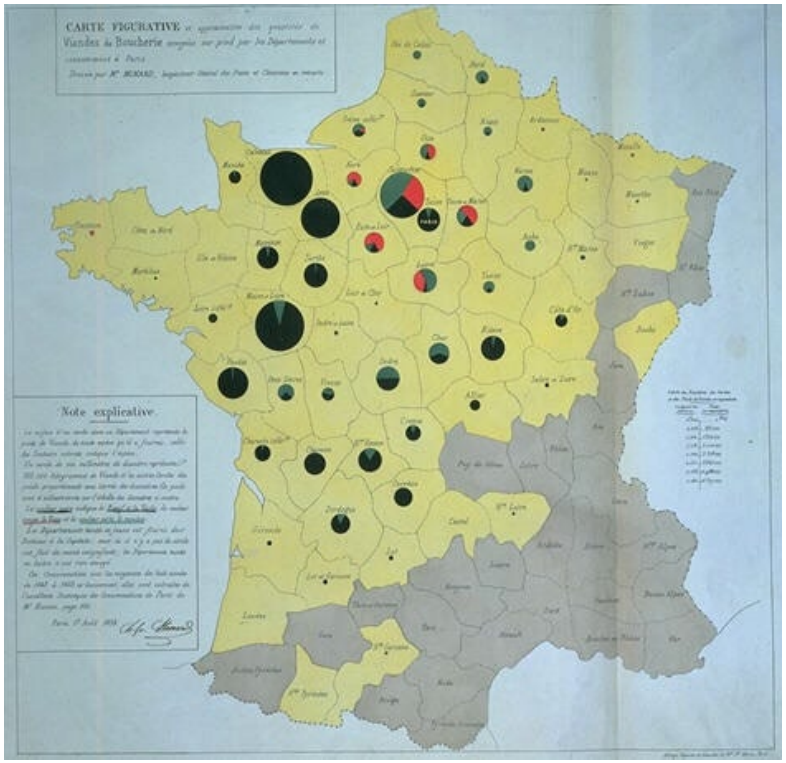
Data visualization: Diffusion of ideas

- Graphical inventions often applied to maps
  - Playfair (1805): pie chart -> Minard (1858): pie map

What are the sizes of US territories?



Where does meat sold in Paris come from?



Stories from the Golden Age (1850-1900)

Stories:

- A.-M. Guerry & the rise of social science
- Graphic vision of C. J. Minard
- Galton's graphical discoveries
- Statistical albums

Themes:

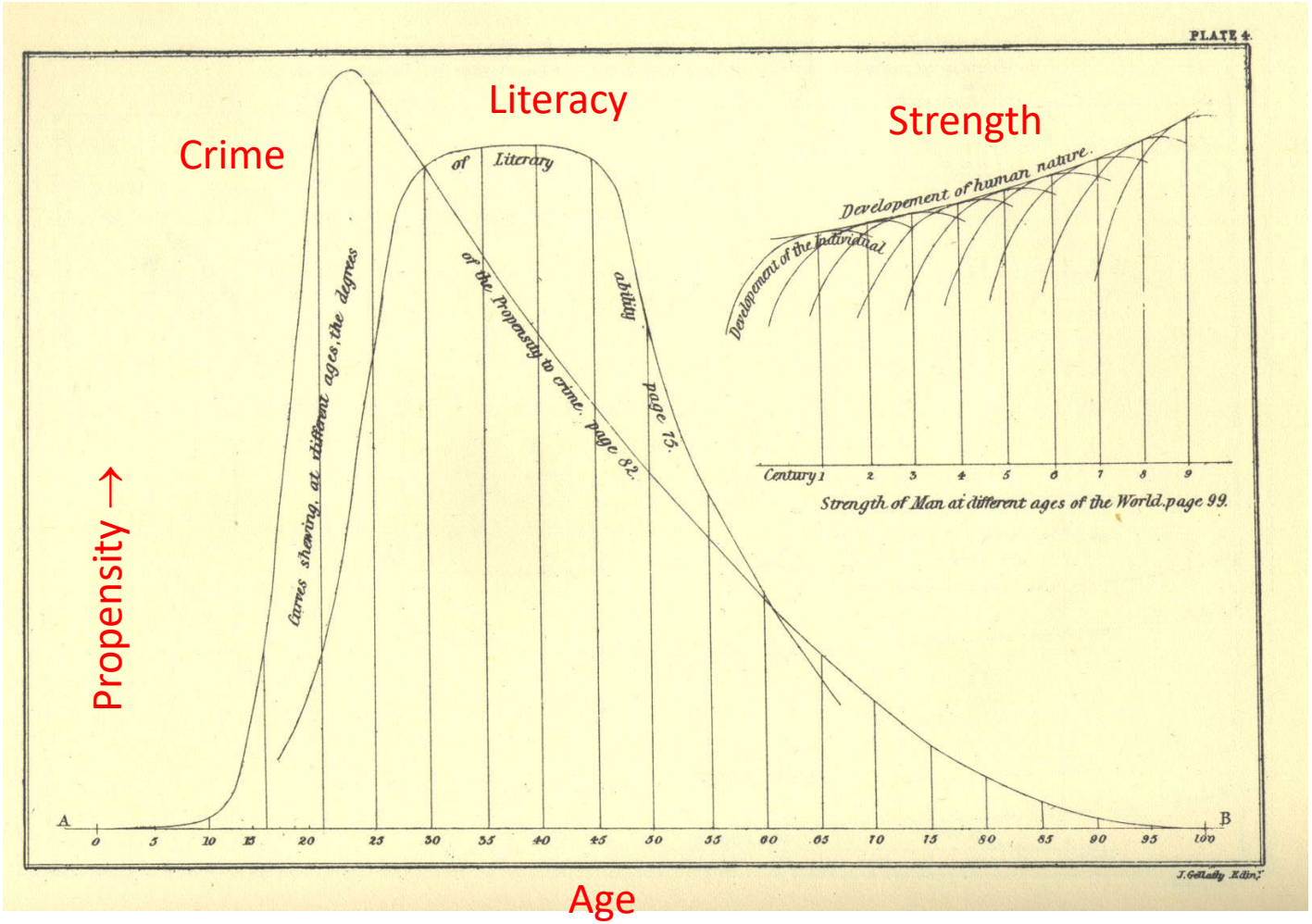
- Statistics: numbers of the state
- Rise of visual thinking
- Escaping flatland: 2D $\rightarrow$ 3D
- Visualization $\rightarrow$ Theory (graphic discovery)
- Data $\rightarrow$ Theory $\rightarrow$ Practice
- Graphical excellence

Big questions of the early 1800s

- Issues for European states
  - Demography: taxes, raising an army (Süssmilch, 1741)
  - "Statistik": Numbers of the state (Achenwall, 1748)
  - Social problems: crime, suicide, literacy, etc.
  - Disease epidemics, e.g., cholera
- Anthropometry: the measure of Man
  - Distributions of human characteristics (Quetelet)
  - Mortality, suicide, propensity to crime
- Beginnings of statistical theory and application
  - Normal dist^{n} (de Moivre, 1733)
  - *L'homme moyen* (Quetelet, 1835)

Quetelet: Anthropometry

Quetelet (1842), *A Treatise on Man and the Development of His Faculties*, uses graphs to illustrate various themes: measurement, graphical comparison, …



Human characteristics could be measured and studied graphically

Big data of the early 1800s:
"An avalanche of social numbers"

- J.-B.J. Fourier: *Recherches statistique sur la ville de Paris* (1821-1829)
  - Massive tabulations: births, deaths (by cause), admission to insane asylums (age, sex, affliction)
- Ministry of Justice: *Compte generale (1825--)*
  - First national compilation of criminal justice data
  - All charges & dispositions, quarterly, 86 departments
- Other sources:
  - Bureau de Longitudes (illegitimate births)
  - Parent-Duchatelet (prostitution); Min. of War (desertions)
  - Suicide notes in Paris collected and analyzed for motives
- Social issues could now be addressed with **DATA**

1. A. M. Guerry and the rise of social science

Essai sur la statistique moral de la France

The launching pad of modern social science

- Presented to Academie des Sciences Français July 2, 1832
- First systematic analysis of comprehensive data on crime, suicide, and other social variables.
- Along with Quetelet (1831, 1835), established the study of "moral statistics" ⟼ modern social science, criminology, sociology

LIBRAIRIE SCIENTIFIQUE DE CROCHARD, ÉDITEUR,
Place de l'École-de-Médecine, n. 13.

ESSAI
SUR
LA STATISTIQUE
MORALE
DE LA FRANCE,
PAR
A. M. GUERRY,

PRIX : 15 FRANCS.

Ouvrage qui a obtenu le prix de statistique décerné en 1833
PAR L'ACADÉMIE ROYALE DES SCIENCES.

Social context of crime in 1820s France

- Crime a serious concern:
  - Explosive growth in Paris after Napoleon's defeat (Waterloo, 1815)
  - Widespread unemployment,
  - Emergence of perception of "dangerous classes": what to do???
    - Victor Hugo (*Les Misérables*); Honoré de Balzac; Emile Zola
- Liberal ("philanthrope") view:
  - Increase education
  - Better prison conditions, diet (bread ***and*** soup)
  - Religious instruction
- Conservative view:
  - Build more prisons; longer prison sentences
  - Harsher treatment of recidivists
- Now, there was finally some DATA!

The discovery of "social facts"

Stability and Variation

Guerry's results were both compelling and startling:

- Rates of crime and suicide remained remarkably invariant over time, yet varied sytematically by region, sex of accused, type of crime, etc.
- In any given French city or department, almost the same number committed suicide, stole, gave birth out of wedlock, etc.

Year	1826	1827	1828	1829	1830	Avg
Sex			All accused (%)			
Male	79	79	78	77	78	78
Female	21	21	22	23	22	22
Age			Accused of Theft (%)			
16–25	37	35	38	37	37	37
25–25	31	32	30	31	32	31
Crime			Committed in summer (%)			
Indecent assault	.	36	36	35	38	36
Assault & battery	.	28	27	27	27	28

OMG! ~ constant → 79

OMG! ~ constant → 31

"We are forced to conclude that the facts of the moral order are subject, like those of the physical order to invariable laws." (Guerry, 1833, p14)

The discovery of "social facts"

Social laws á la physical laws

Do crime and other moral variables represent:

- structural, lawful characteristics of society, or are they
- simply indicants of individual behaviour?

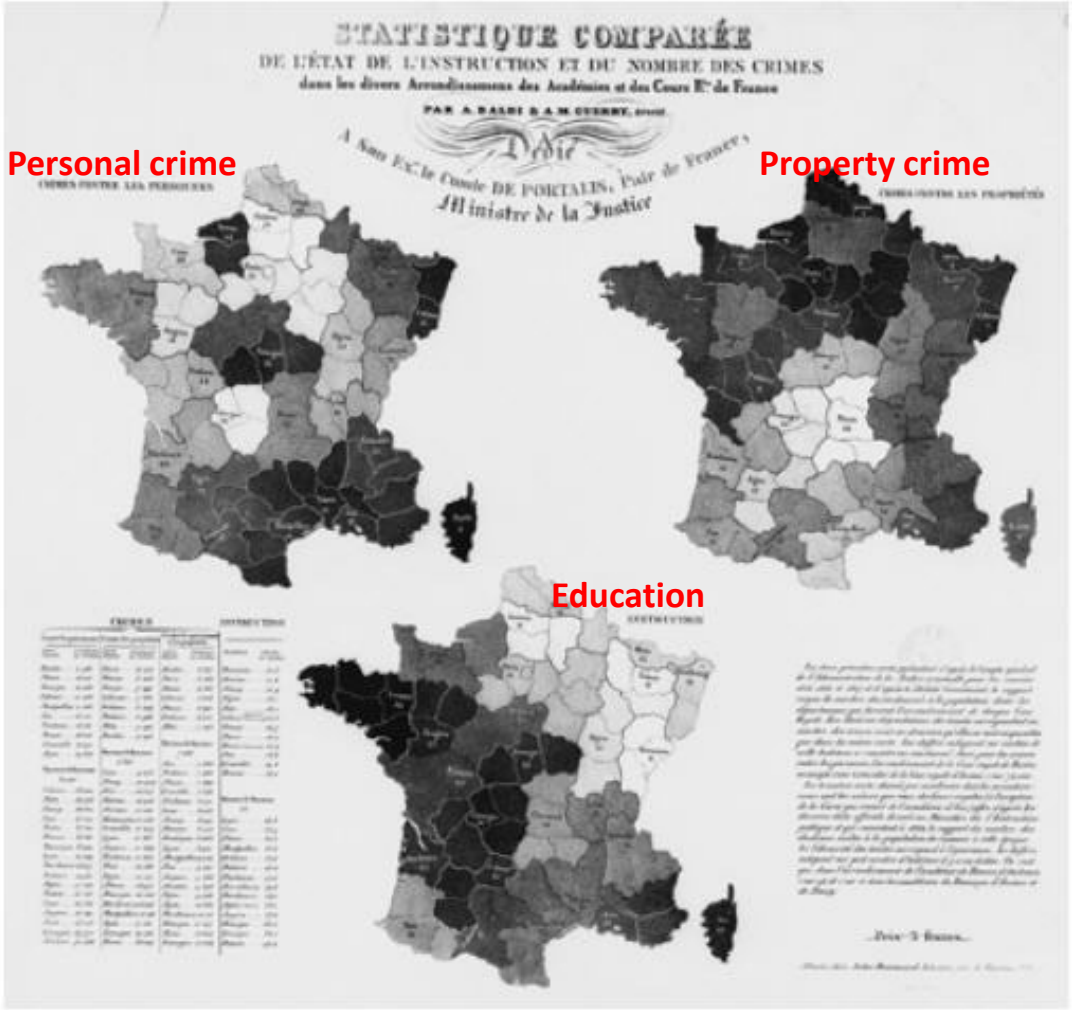
Guerry argued:

Each year sees the same number of crimes of the same degree reproduced in the same regions.(Guerry, 1833, p.10)

... We are forced to recognize that the facts of the moral order are subject, like those of the physical order, to invariable laws (Guerry, 1833, p14)

1829: *Statistique comparée de l'état de l'instruction...*

- First shaded thematic maps of crime data
- First comparative maps of social data
- $\mapsto$ crime against persons seemed inversely related to crime against property!
- Instruction: $\mapsto$ *France obscure* and *France éclairée* (Dupin, 1826)
- North of France highest in education, but also in property crime!

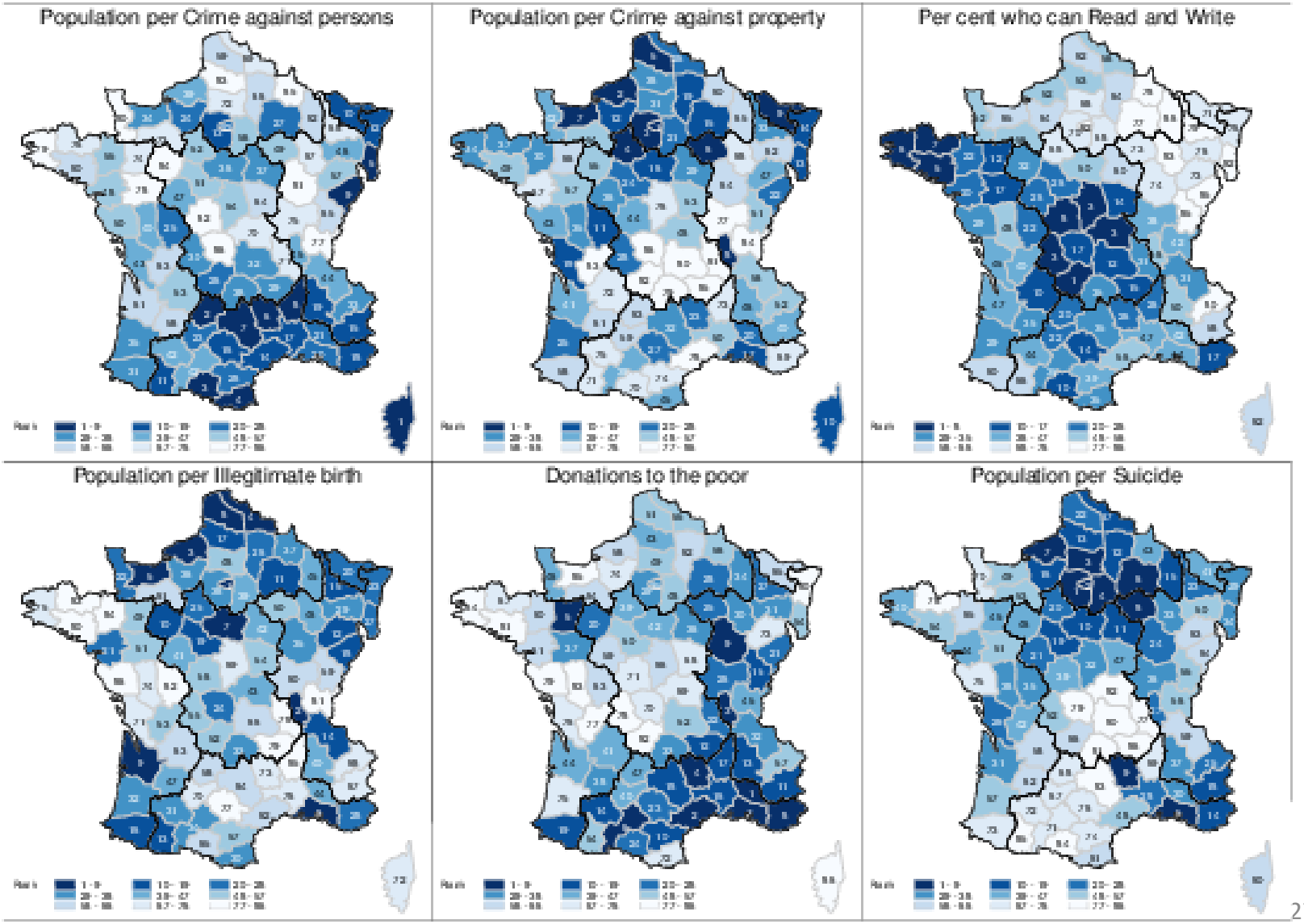


1833: *Essai sur la statistique morale de la France*

- Divided the 86 departments into 5 regions
- Supplemented data from the *Compte général* with:
  - Suicides in Paris, 1794–1832
  - Prostitutes in Paris (Parent-Duchâtelet)
  - Wealth (taxes per inhabitant)
  - Distribution of clergy
  - ...
- First study to use crime data to 'test' hypotheses
- Attracted widespread interest in Europe

Guerry's 1833 map of literacy in France

Guerry's moral variables



1864: *Statistique morale de l'Angleterre comparée...*

Dayenu!

- Proposes to replace simple "moral statistics" (tables) with "analytical statistics"
  - calculation, graphic display
  - $\mapsto$ general, abstract results
- 17 large color plates (56 $\times$ 39 cm):
  - data for France (1825–1855), England (1834–1855)
  - crimes against persons and property decomposed in various ways
  - first attempt to delineate multivariate relations among moral variables
- Voluminous data:
  - 85,564 suicide records (1836–1860), classified by motive
  - 226,224 accused of personal crime
  - numbers, in a line $\rightarrow$ 1170 meters!

STATISTIQUE MORALE

DE

L'ANGLETERRE

COMPARÉE AVEC

LA STATISTIQUE MORALE

DE

LA FRANCE

PAR A.-M. GUERRY

ATLAS

PROSPECTUS

PARIS

J.-B. BAILLIÈRE ET FILS,

LONDRES, NEW-YORK,

MADRID.

Further details: Friendly, M. (2007). A.-M. Guerry's *Moral Statistics of France:* Challenges for Multivariable Spatial Analysis, *Statistical Science, 22*, 368-399

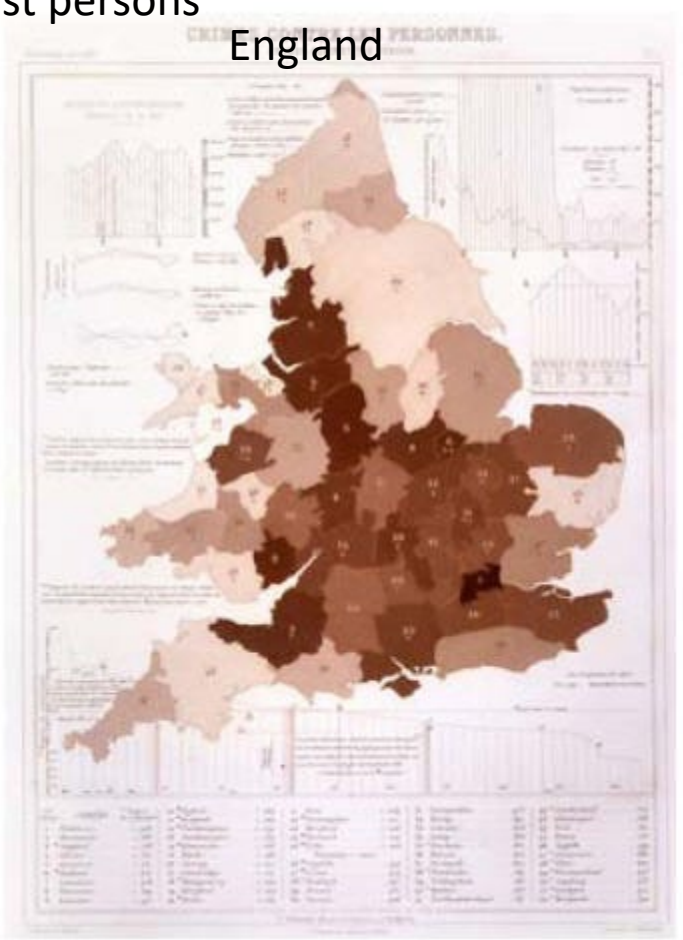
1864: *Statistique morale de l'Angleterre comparée...*

Comparing France and England

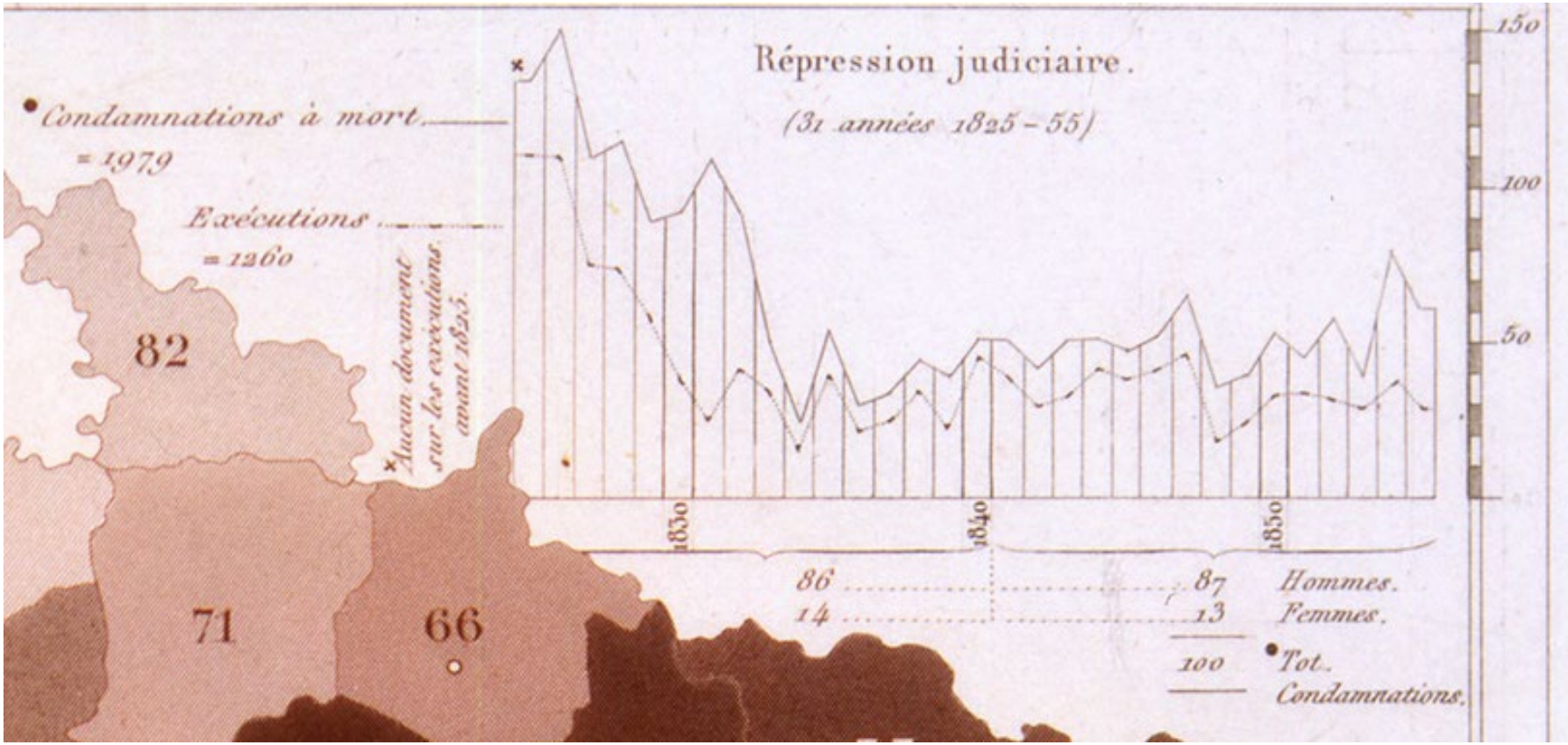
Crimes against persons

France

England



Graphs and tables around the outside give details: data, trends over time, or season, …



Detail: Trends in death sentences and executions over 31 years

Statistique analytique: General causes of crime

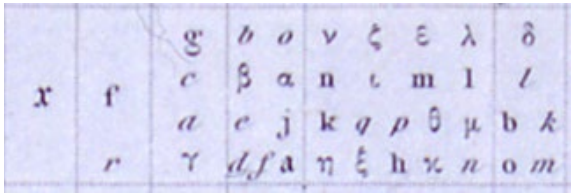
Plate XVII: M. Guerry's magnum opus

Goal:

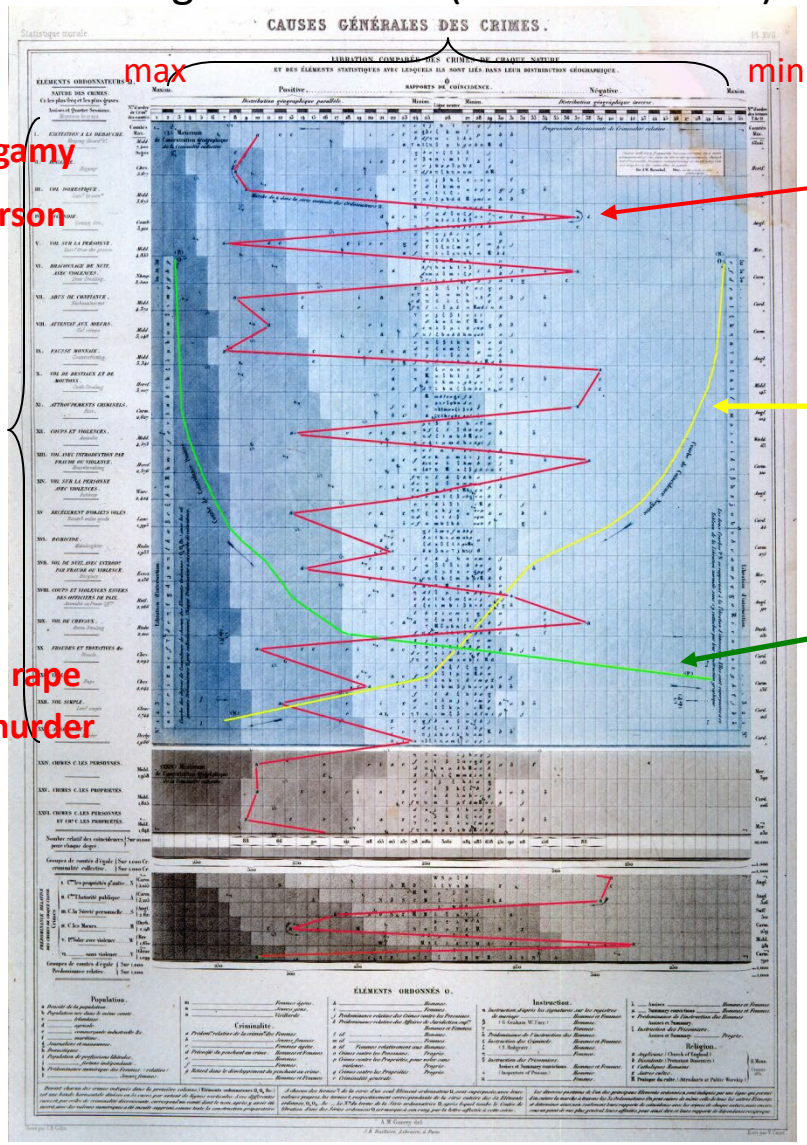
- Show multivariate factors associated with distribution of crime
- Before invention of correlation

Entries: Codes for factors

- Pop: (% Irish, domestics, …)
- Criminality: (male, young, …)
- Religion (Anglicans, dissenters, …)



English counties (ranked on each)

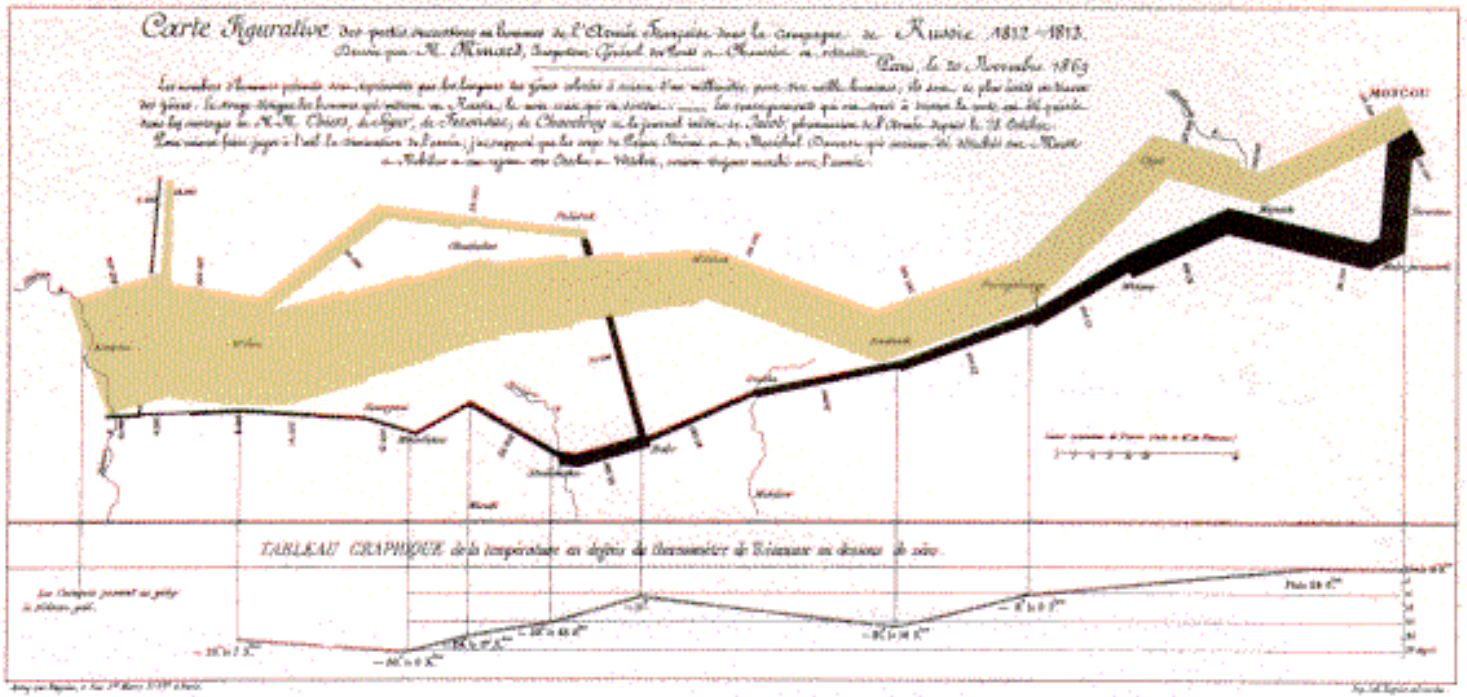


High pop. density

Curve of neg. association

Curve of pos. association

2. The graphic vision of C. J. Minard



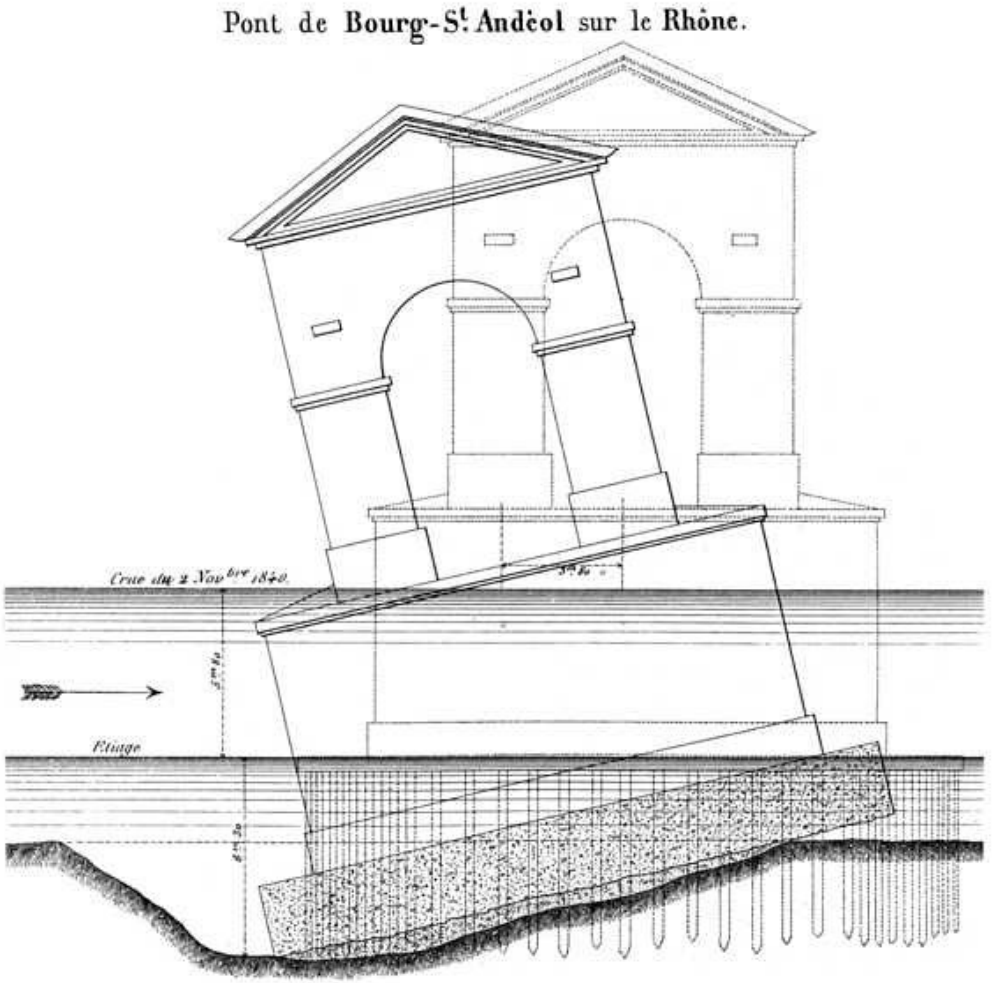
- Marey (1878): *"defies the pen of the historian in its brutal eloquence"*
- Tufte (1983): *"the best statistical graphic ever produced"*

Visual thinking, visual explanation

Minard's main career was a as a civil engineer for the ENPC (bridges & roads)

1840: Why did the bridge at Bourg-St. Andèol collapse?

Minard's report consisted essentially of this self-explaining diagram.



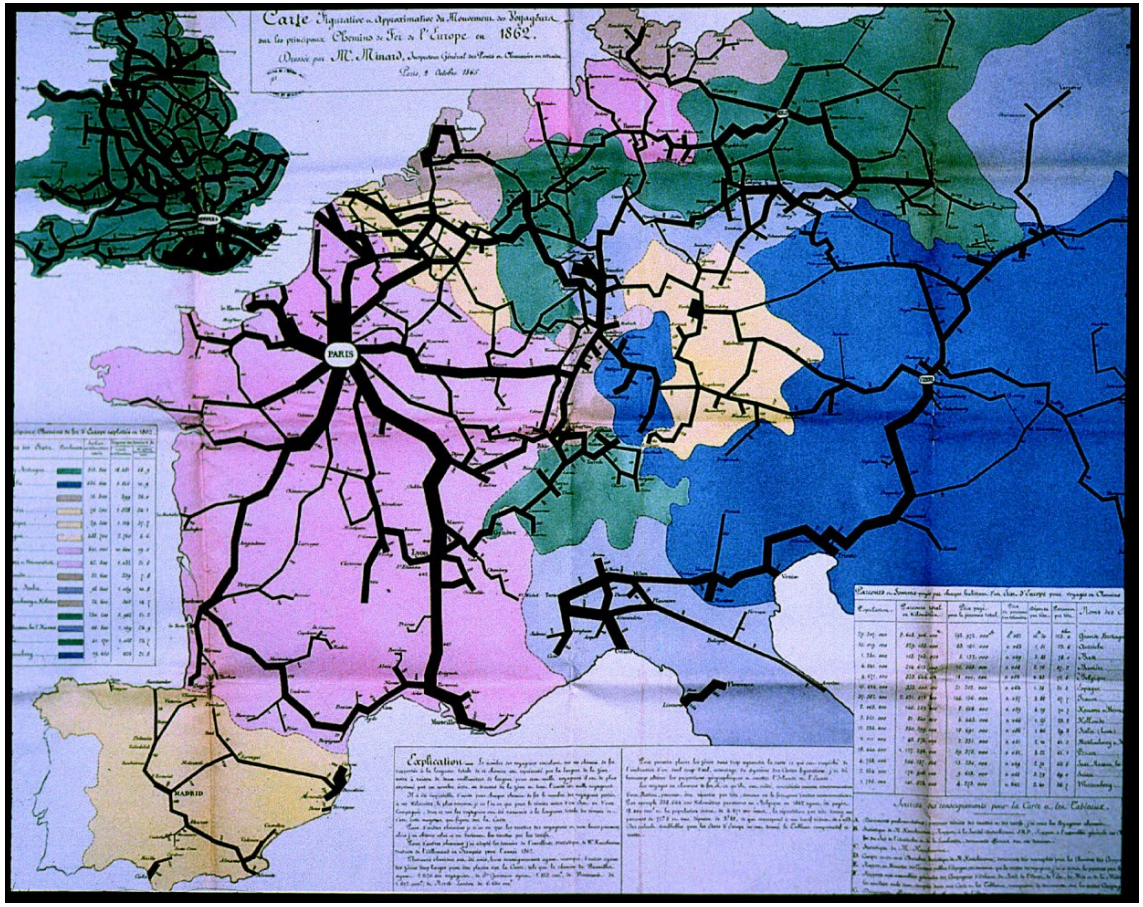
Big questions of the mid 1800s

- 1830—1860: emergence of modern French state, dawn of globalization
- Trade, commerce, transportation:
  - Where to build railroads, canals?
  - How to compete with imports/exports?
  - Visualizing changes over time, differences over space
  - $\rightarrow$ Flow maps and other graphical innovations
- These questions motivated the "Golden Age" of statistical graphics.
  - data, statistics, technology & visual thinking

See: Friendly, M. (2008). The Golden Age of Statistical Graphics, *Statistical Science, 23*, 502-535, https://www.datavis.ca/papers/golden-age.pdf

Flow maps as visual tools

Transport of passengers on the principal railroads in Europe in 1862



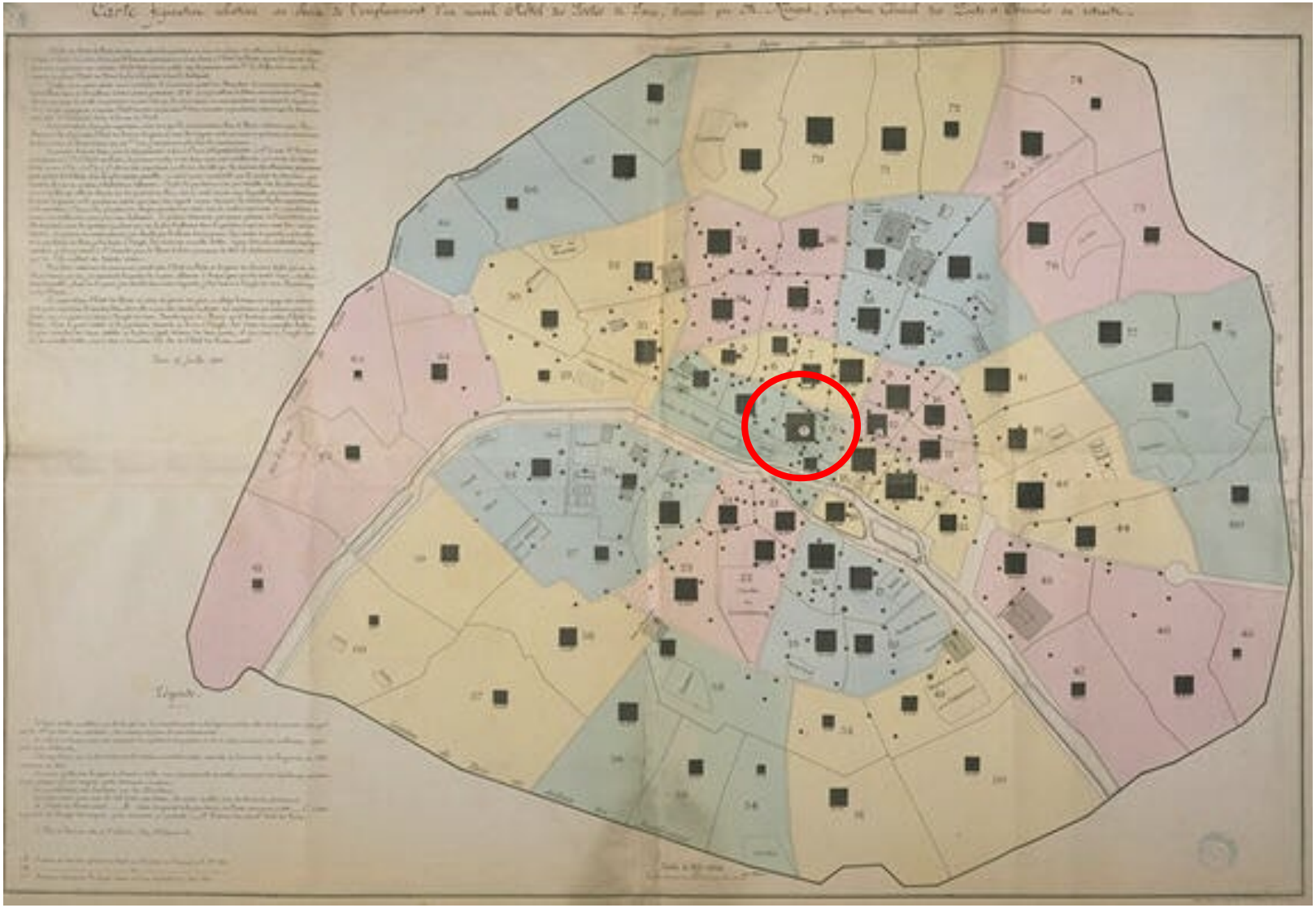
The dominant principle which characterizes my graphic tables and my figurative maps is to make immediately appreciable to the eye, as much as possible, the proportions of numeric results.

...Not only do my maps speak, but even more, they count, they calculate by the eye.

-- Minard (1862)

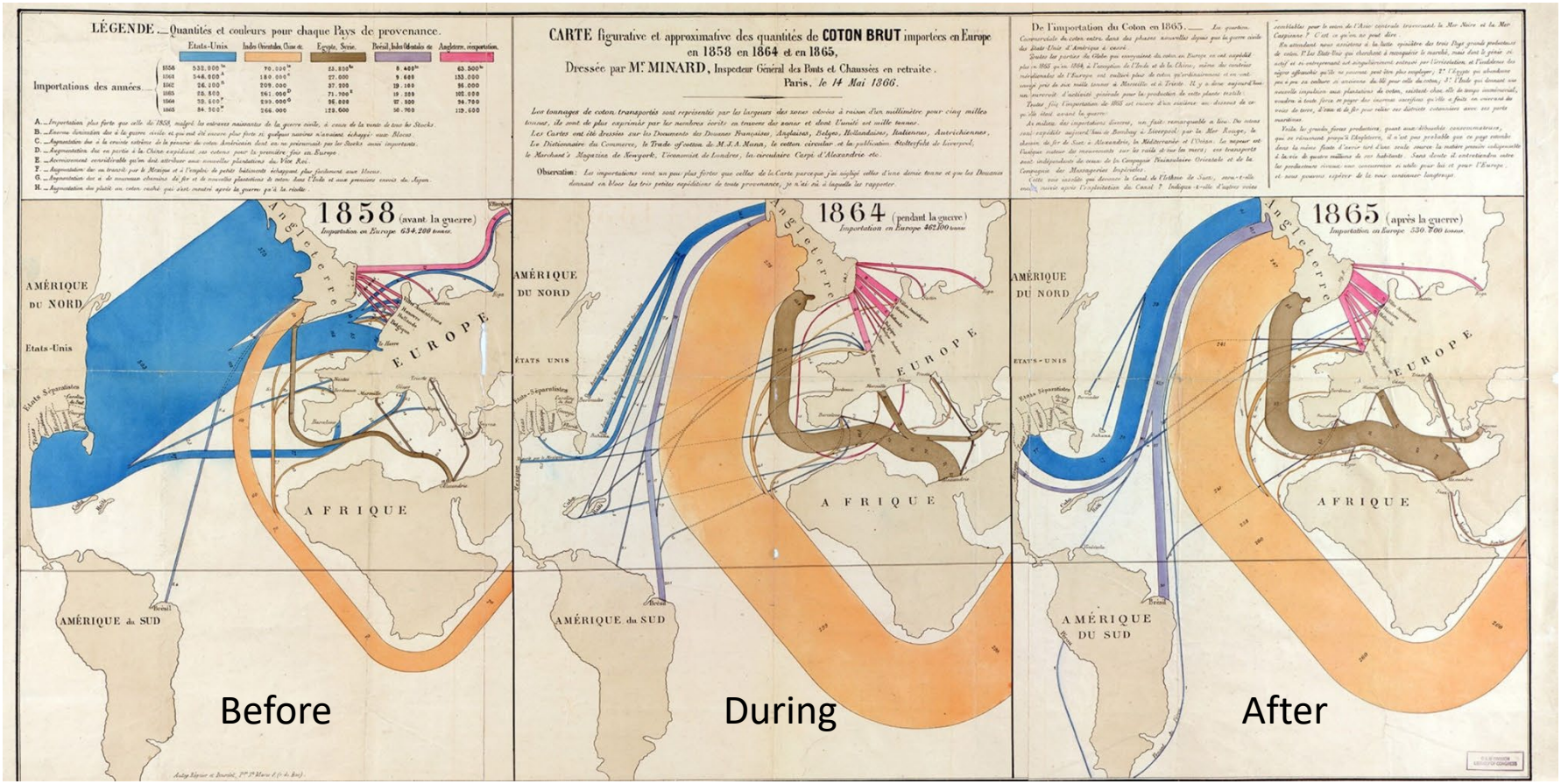
Q: Where to build a new post office in Paris?

- Visual solution: at the center of gravity of population



Visual explanation

What was the effect of the US Civil War on trade in cotton?

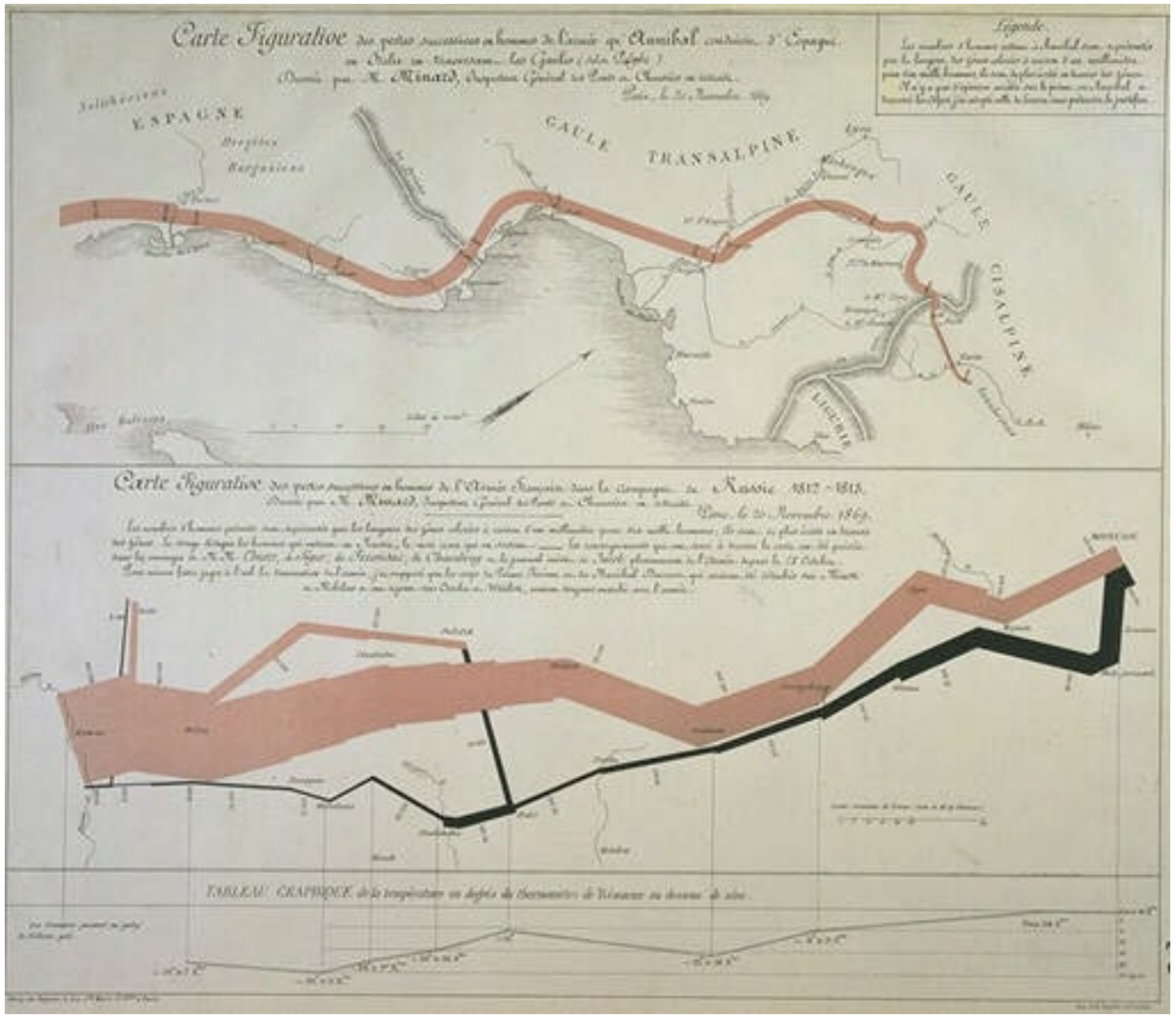


"Carte figurative et approximative des quantités de coton brut importées en Europe en 1858, en 1864 et en 1865" by Charles Joseph Minard (1866)

The March Re-Visited (1869)

Hannibal's retreat

Napoleon's 1812 campaign



Les Chevaliers: Minard's Tomb

Recent discovery of Minard's tomb in Montparnasse Cemetery, Paris.

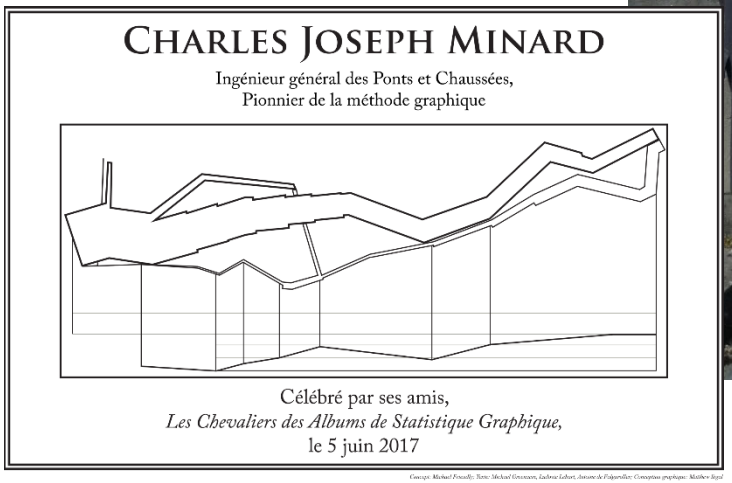
Celebrated June 5, 2017

Jean-Pierre Airey-Jouglard

Antoine de Falguerroles

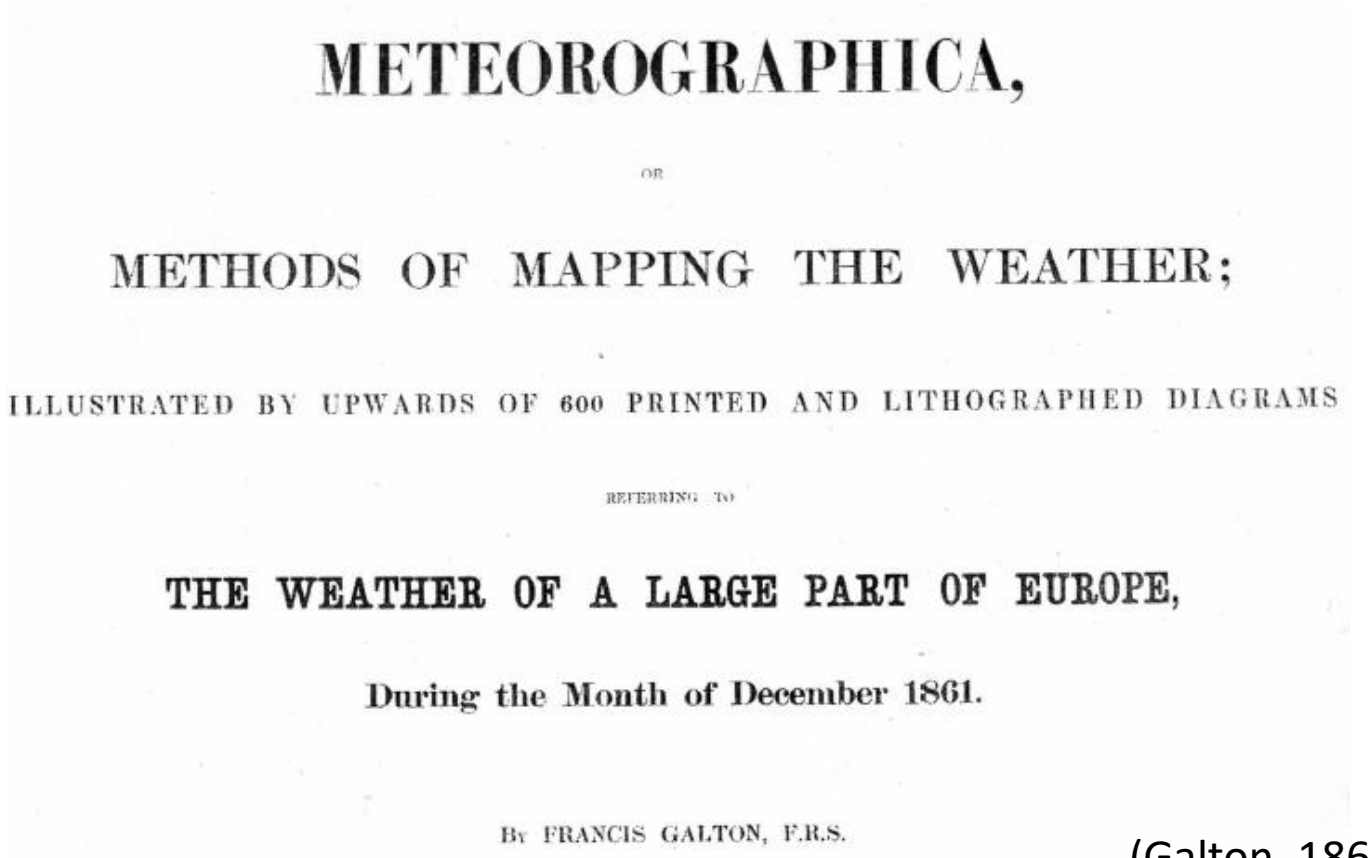
MF

Gilles Palsky



3. Galton's discovery of weather patterns-

Perhaps the most notable *purely graphic* discovery ever!



METEOROGRAPHICA,

OR

METHODS OF MAPPING THE WEATHER;

ILLUSTRATED BY UPWARDS OF 600 PRINTED AND LITHOGRAPHED DIAGRAMS

REFERRING TO

THE WEATHER OF A LARGE PART OF EUROPE,

During the Month of December 1861.

By FRANCIS GALTON, F.R.S.

(Galton, 1863)

Method: All weather stations across Europe asked to record data 3x/day for all of Dec., 1861

Galton's data collection form:

Contributors, according to the Conditions of my Circular Letter, are requested to enter their Observations in one of the blank forms, to enclose it in a stamped envelope, and to post it to my address on January 1st, 1862.

FRANCIS GALTON,
42, *Rutland Gate, London.*

Name of Station :
Its Latitude :
Its Longitude from Greenwich :
Its Height above Sea Level, in English Feet :

Name of Contributor :

Full Address to which the Charts are to be forwarded when ready :

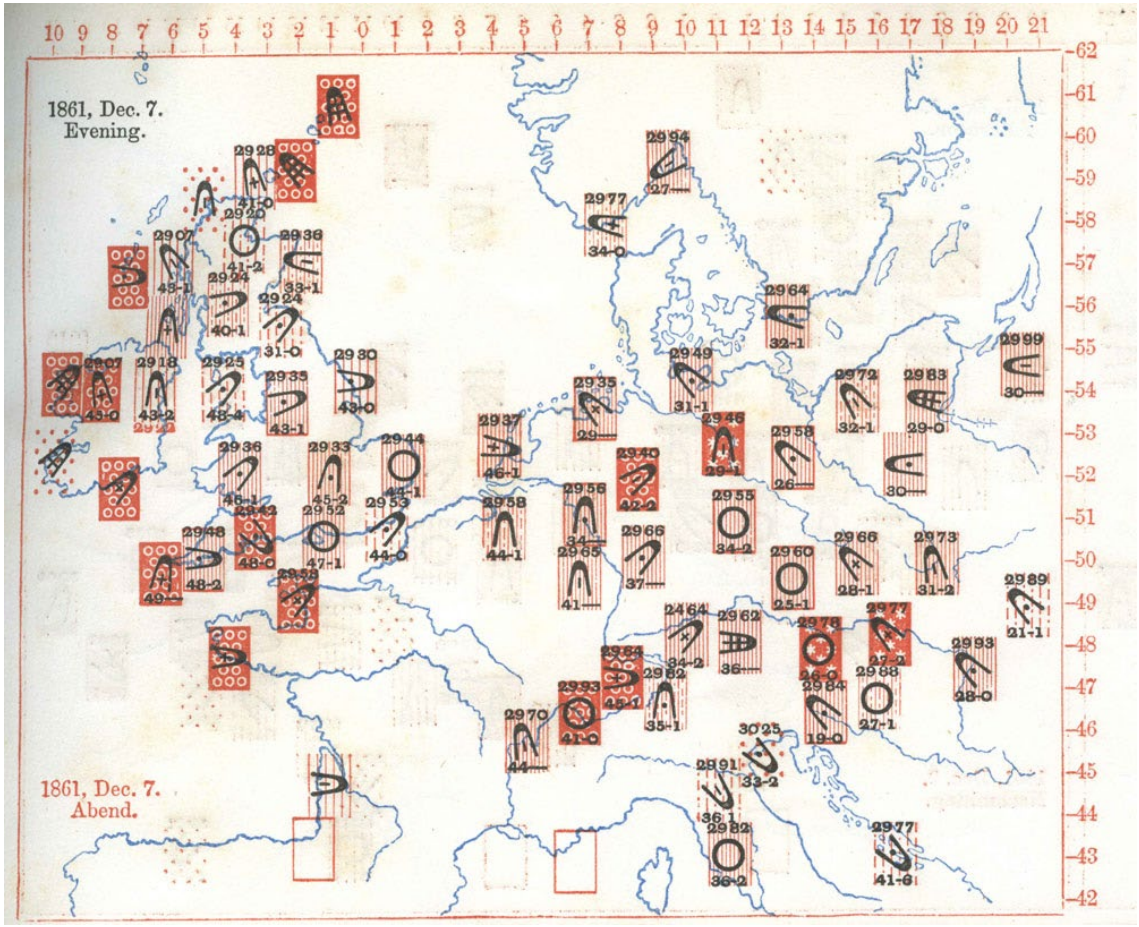
Date. Either Local or Railway Time; state which. **December 1861.**		Barometer corrected to Freezing Point at Mean Sea Level, and reduced to English Inches, Tenths, and Hundredths.	Exposed Thermometer in Shade, to nearest Degree, Fahrenheit.	Moistened Bulb to nearest Degree, Fahrenheit, for Evaporation and Dew Point.	Direction of Wind, *true* not magnetic. Only 16 points of the Compass are used; as, N., N.N.E., N.E., E.N.E., E., &c.	Force of Wind: Calm, Gentle, Moderate, Strong, Gale.	Amount of Cloud: Clear blue sky, A few clouds, Half clouded, Mostly clouded, Entirely clouded, Entirely and heavily clouded.	Rain, Snow, or neither.	Remarks.
1	9 A.M.								
	3 P.M.								
	9 P.M.								
2	9 A.M.								
	3 P.M.								
	9 P.M.								
3	9 A.M.								
	3 P.M.								
	9 P.M.								

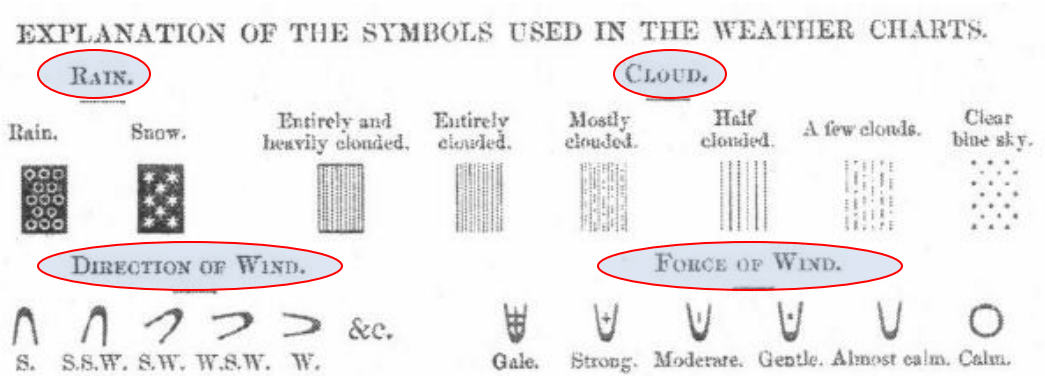
Method: All weather stations across Europe asked to record data 3x/day for all of Dec., 1861

Data: recordings of barometric pressure, wind dir/speed, rain, temp., cloud: 3x/day, 50 weather stations in Europe.

Graphic analysis: 3x31=93 maps, each with multivariate glyphs showing all variables

Visual ideas:
- Iconic symbols
- Multivariate glyphs (stamps!)





Visual abstraction → Patterns

How to see patterns of geographical variation over time?

- Iconic symbols on a geographical grid
- "Small multiples:" separate graphs laid out for direct comparison

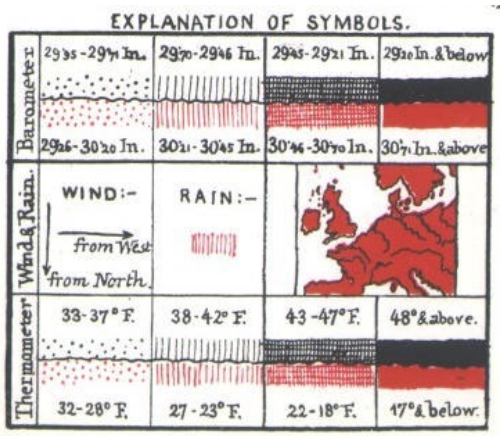
Symbols in Barometrical Charts.

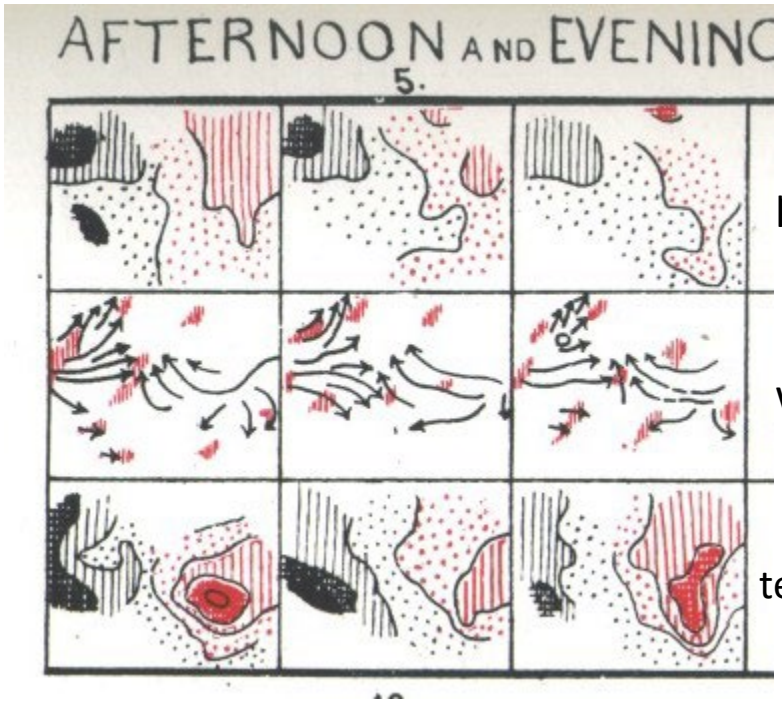
	Inches. Inches.	Inches. Inches.	Inches. Inches.	Inches.
Black -	29.95 to 29.71	29.70 to 29.46	29.45 to 29.21	29.20 and below.
	○	⊙	✳	●
Red -	29.96 to 30.20	30.21 to 30.45	30.46 to 30.70	30.71 and above.

Visual abstraction → Patterns

What varies with what, over time and space?

- mini, abstract maps: vars x TOD
- iso-contours, shading to show equivalence
- arrows to show wind direction





pressure

wind, rain

temperature

AM noon PM

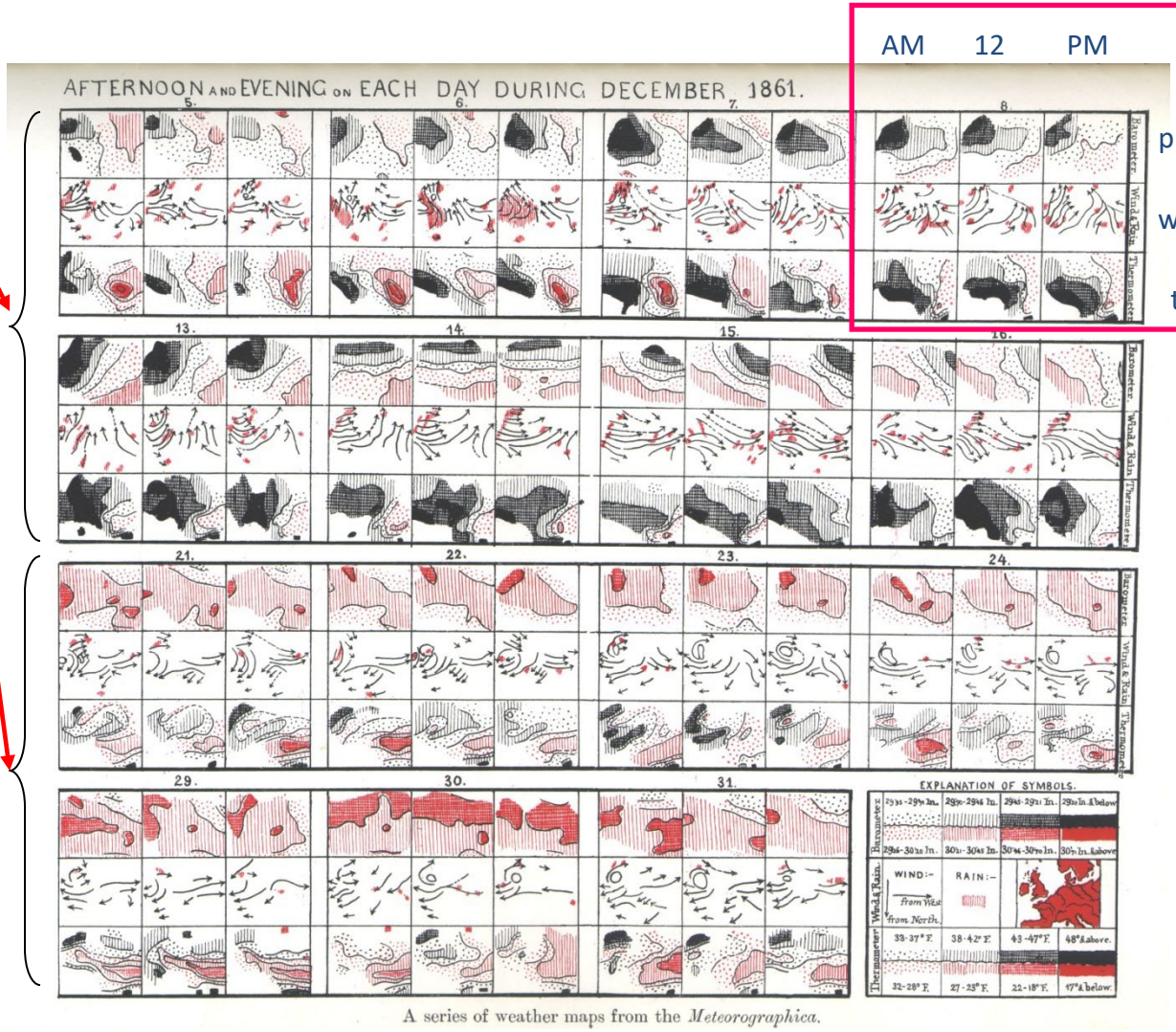
Data for Dec 5, 1861

The large picture → Insight

Pattern:
Low pressure (black) in early Dec. → CCW wind
High pressure (red) in late Dec. → CW wind

Graphic: 3x3x31 grid, mapping {pressure, wind/ rain, temperature} x {AM, 12, PM} x day {1:31}

(try this with your software!)



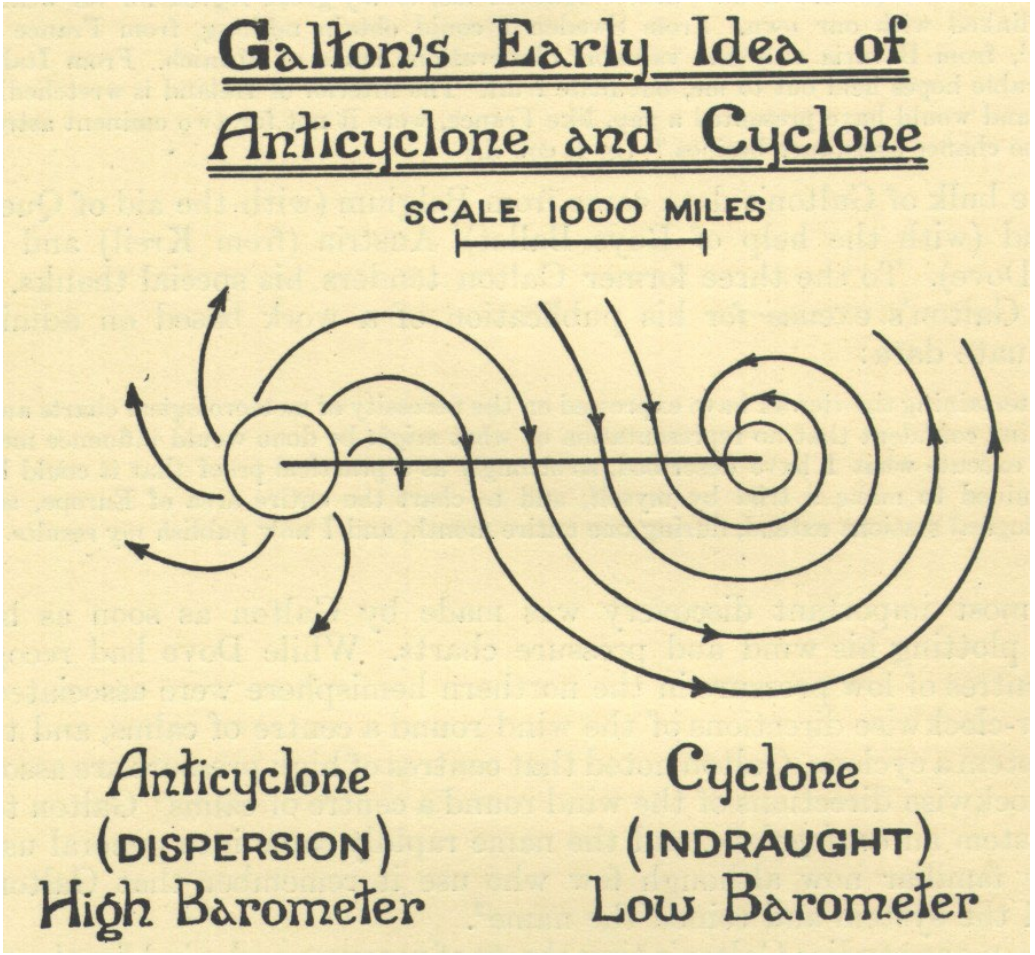
Visual insight → Theory

Visual insight from 93 (3x31) high-D graphs:

- Changes in wind dir w/ pressure over time
- → Winds revolve inwardly (CCW) in low pressure areas– as in a cyclone;
- → revolve outwardly (CW) in high pressure areas– "anti-cyclone"

Theory:

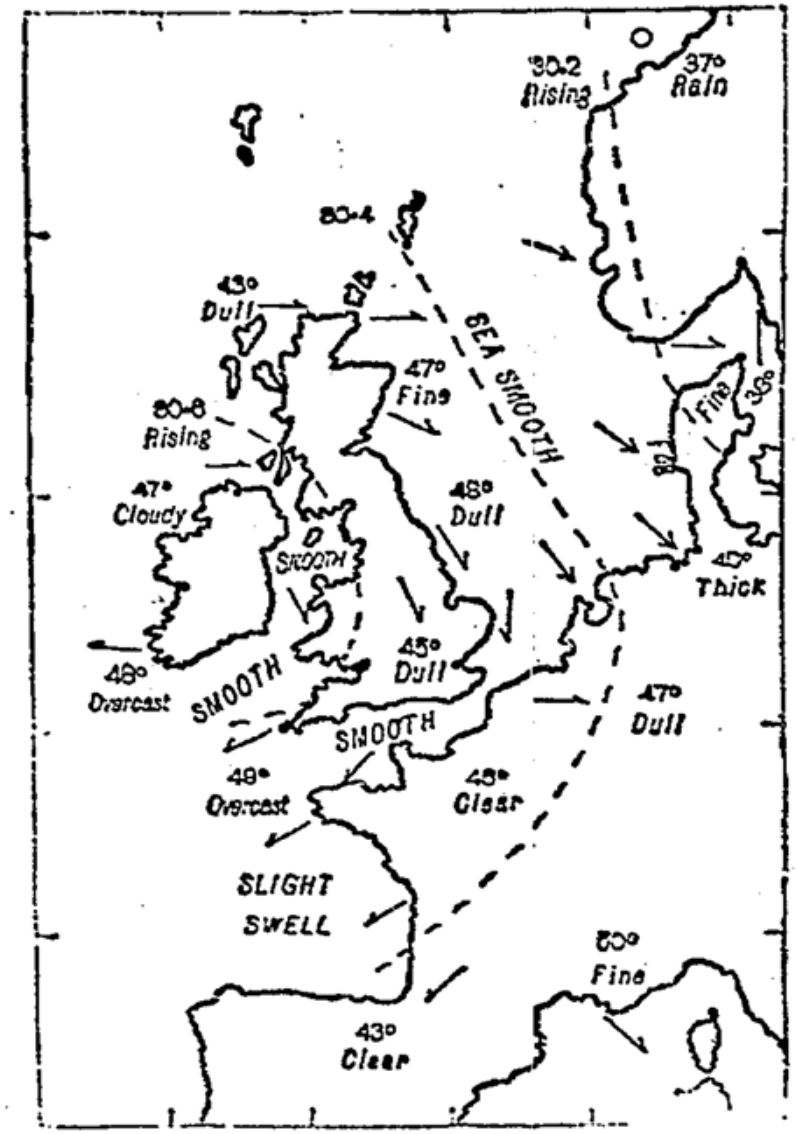
- Explained by Dove's 'Law of Gyration'
- Prediction: reversed pattern (CW/CCW) in southern hemisphere – confirmed!



Theory → Practice

The first modern weather map, *London Times*, Apr. 1, 1875

Galton did for weathermen what Kepler did for Tycho Brahe. This is no small accomplishment. (Wainer 2005)

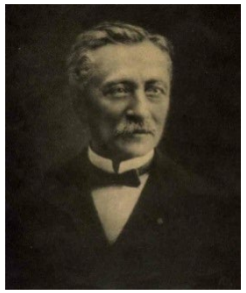


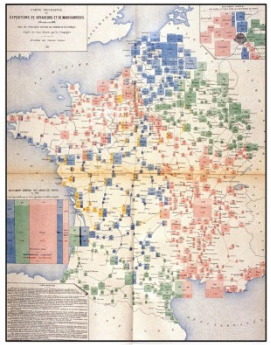
4. Statistical atlases: Data → practice, national identity & graphical excellence

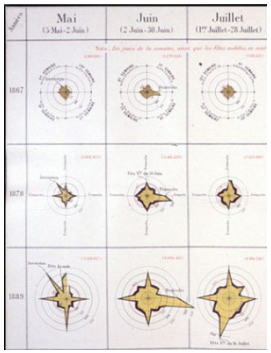
- Collection of gov't statistics on pop., trade, moral & political issues widespread in Europe & US, starting ~ 1820
- Statistical albums ~ 1870—1910
  - France: *Album de Statistique Graphique*: 1879-1899
  - USA: Census atlases: 1870/80/90
  - Germany: local albums (Berlin, Frankfurt, etc.)
  - Switzerland: *Atlas graphique de la Suisse:1897, 1914*
  - *Others: Latvia, Romania, Bulgaria, etc.*

Album de statistique graphique

- Published by the *Statistical Graphics Bureau*, Ministry of Public Works, Émile Cheysson, director
- 18 volumes: 1879-1899, 12—34 plates each, ~ 11”x15” pages
- Graphic forms:
  - Flow maps (simple, double, multi)
  - Pie maps, star, radial, polar time-series, proportional circles
  - Mosaic maps, anamorphic maps, planetary diagrams
  - Choropleth, bi-polar scales
  - Charts: line, bar, time-series
- **Pinnacle of the Golden Age**: exquisite sampler of all known graphic forms!





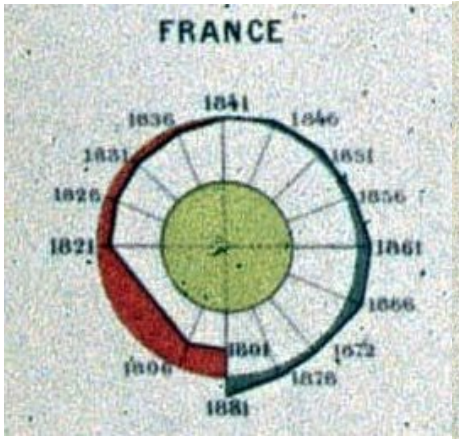


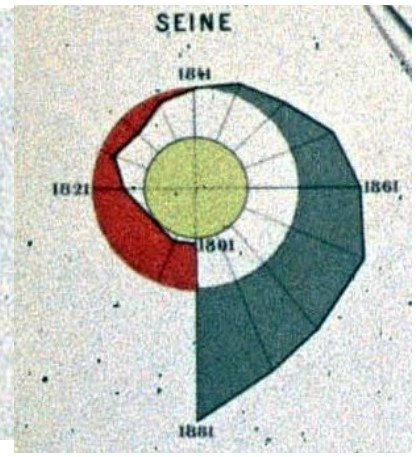
Album de statistique graphique

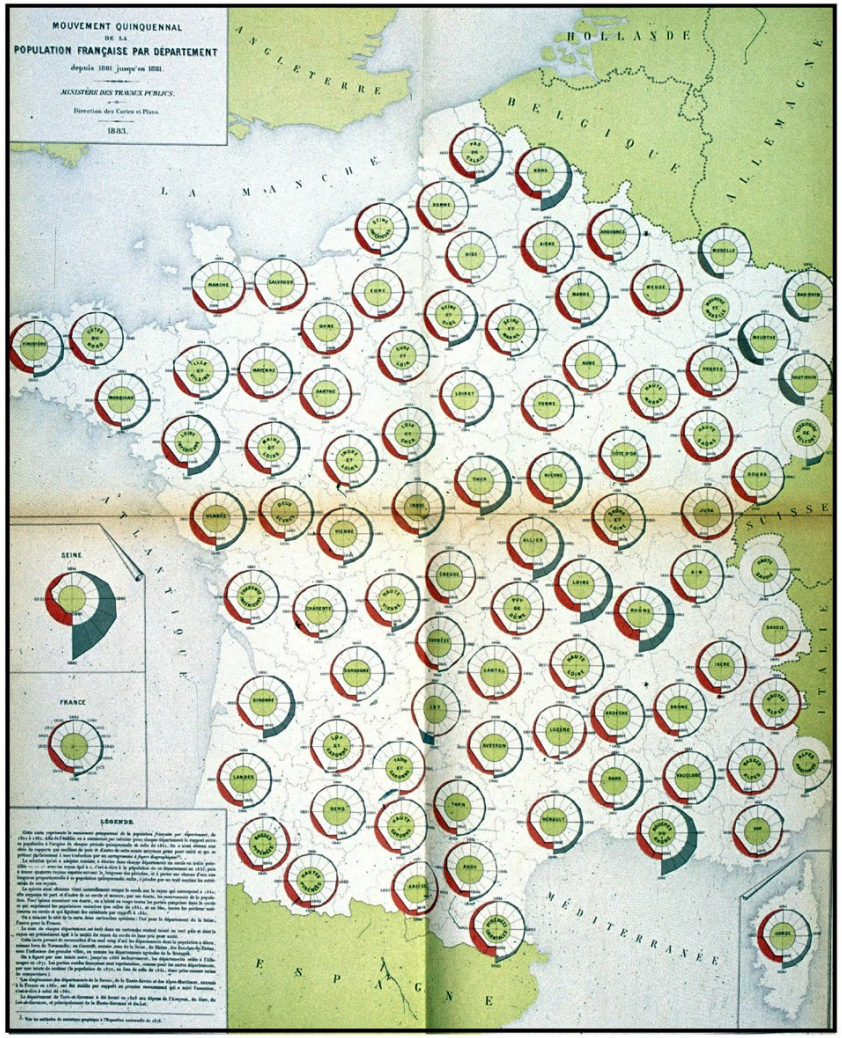
Spiral time-series on a map

Changes in the population of France from 1801—1881, by department [Album, 1881, plate 25]

Where is population growing most? least? declining?



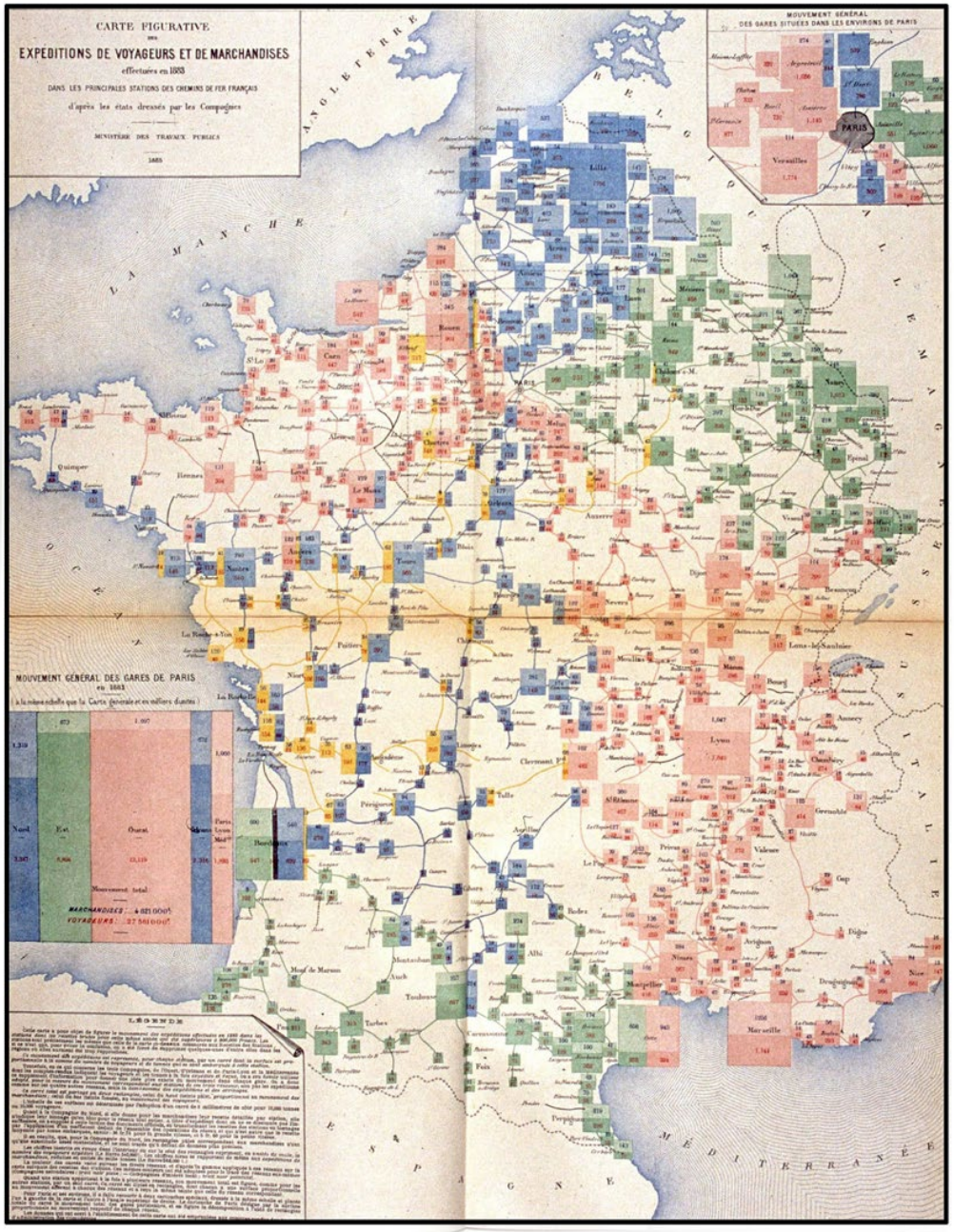




Recursive multi-mosaic map

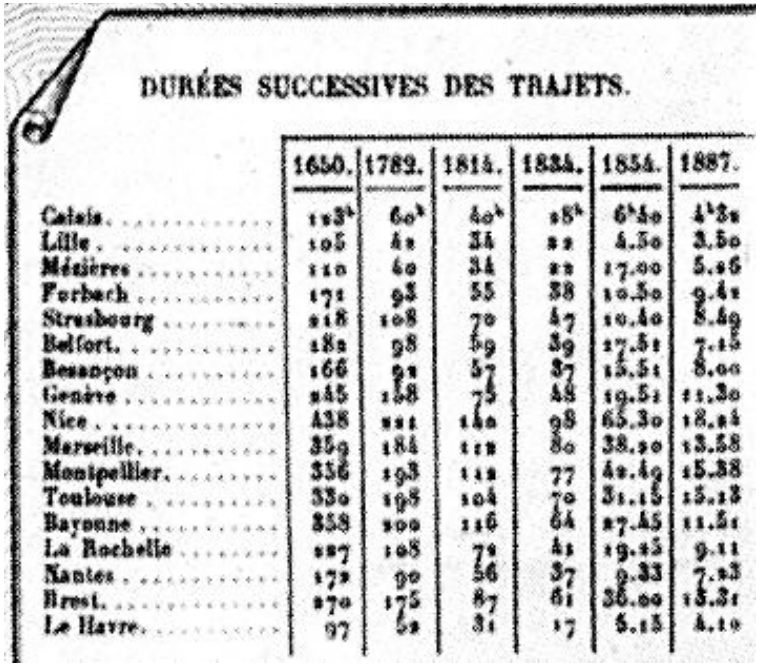
Distribution of **passengers** and **goods** from the Paris railways to the rest of France [Album, 1884, pl. 11]

(The image that launched my interest in the history of data vis.)



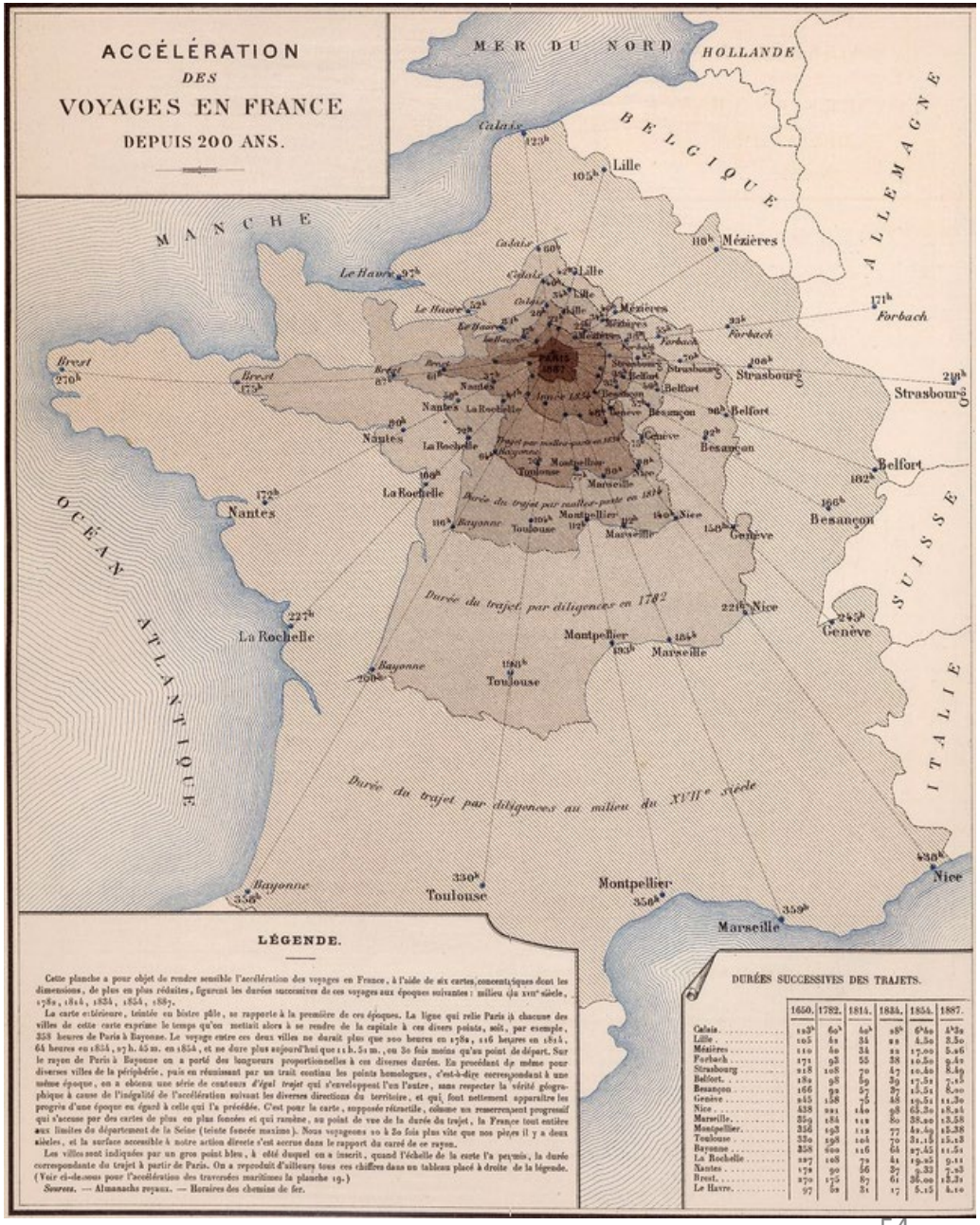
Anamorphic map

Shrinking France to show change in travel time over 200 years [Album, 1888, plate 8]



DURÉES SUCCESSIVES DES TRAJETS.

	1650.	1782.	1814.	1834.	1854.	1887.
Calais	123h	60h	40h	18h	6h40	4h32
Lille	105	42	34	22	4.50	3.50
Mézières	110	60	34	22	17.00	5.26
Forbach	171	93	55	38	10.50	9.42
Strasbourg	218	108	70	47	10.40	8.49
Belfort	182	98	59	39	17.51	7.18
Besançon	166	92	57	37	15.51	8.00
Genève	245	138	76	48	19.51	11.30
Nice	438	221	140	98	65.30	18.24
Marseille	359	184	112	80	38.20	13.58
Montpellier	336	193	112	77	42.49	15.38
Toulouse	330	198	104	70	31.15	15.13
Bayonne	358	200	116	64	27.45	11.51
La Rochelle	227	108	72	41	19.25	9.11
Nantes	172	90	56	37	9.33	7.23
Brest	270	175	87	61	36.00	15.31
Le Havre	97	52	31	17	5.15	4.10

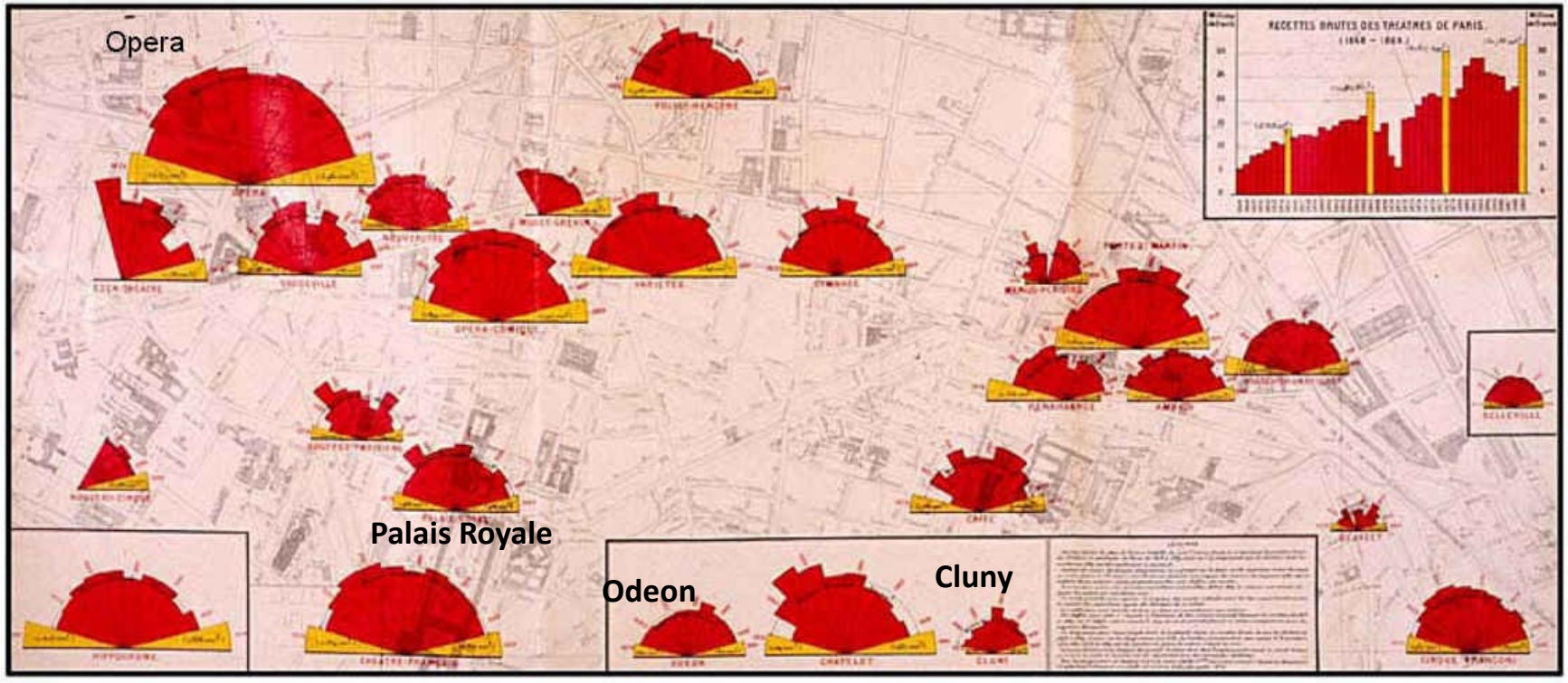


Album de statistique graphique

Q: How did Paris benefit from various int'l expos? How to show this visually?

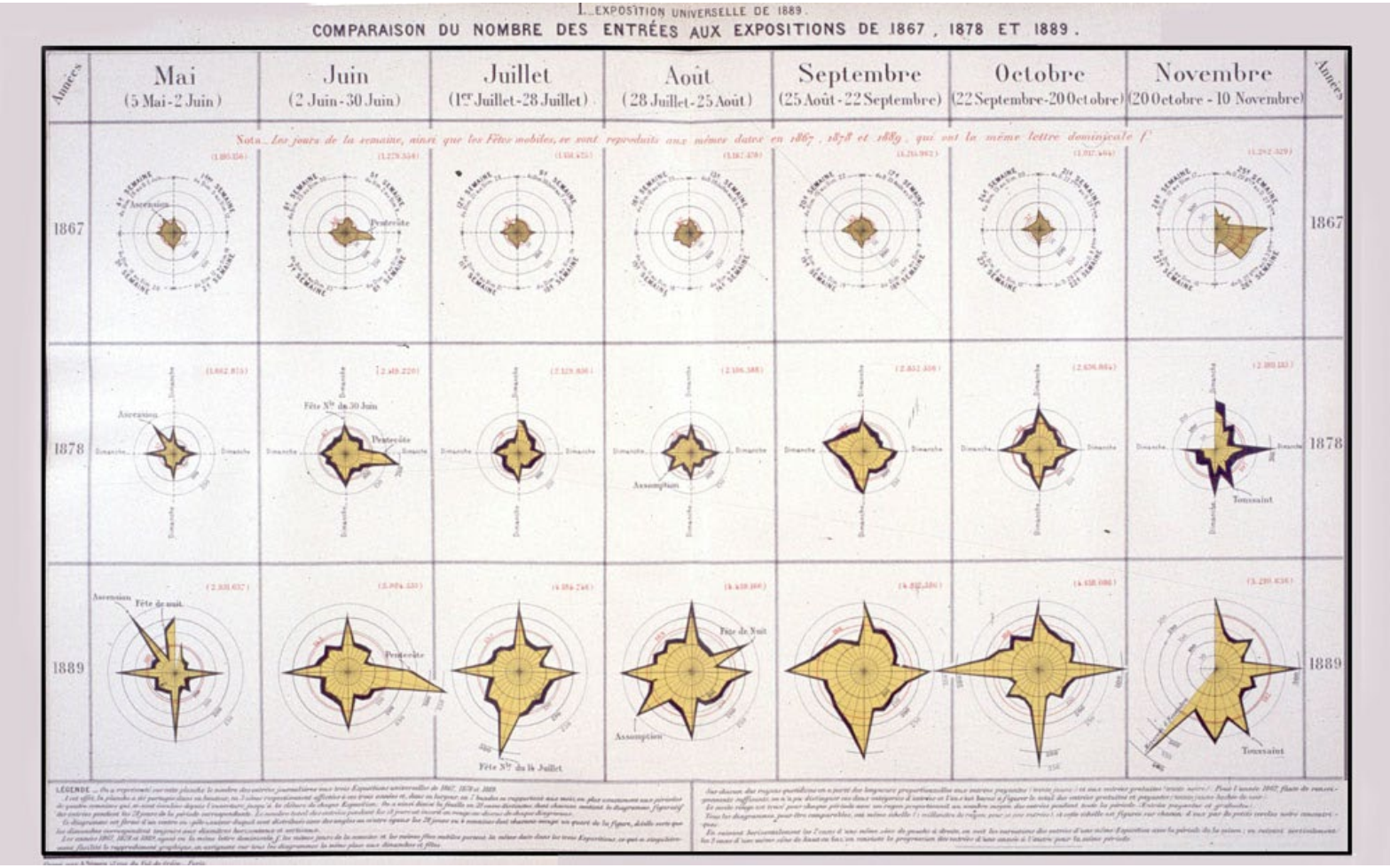
Polar area diagrams on Paris map

Gross receipts in theaters in Paris, 1878—1889, related to universal expositions [Album, 1889, plate 26]



Two-way table of star/radar diagrams

Attendance at the universal expositions in 1867, 1878, 1889 (rows), by month (cols) and days (rays). [Album, 1889, plate 21]



1867

1878

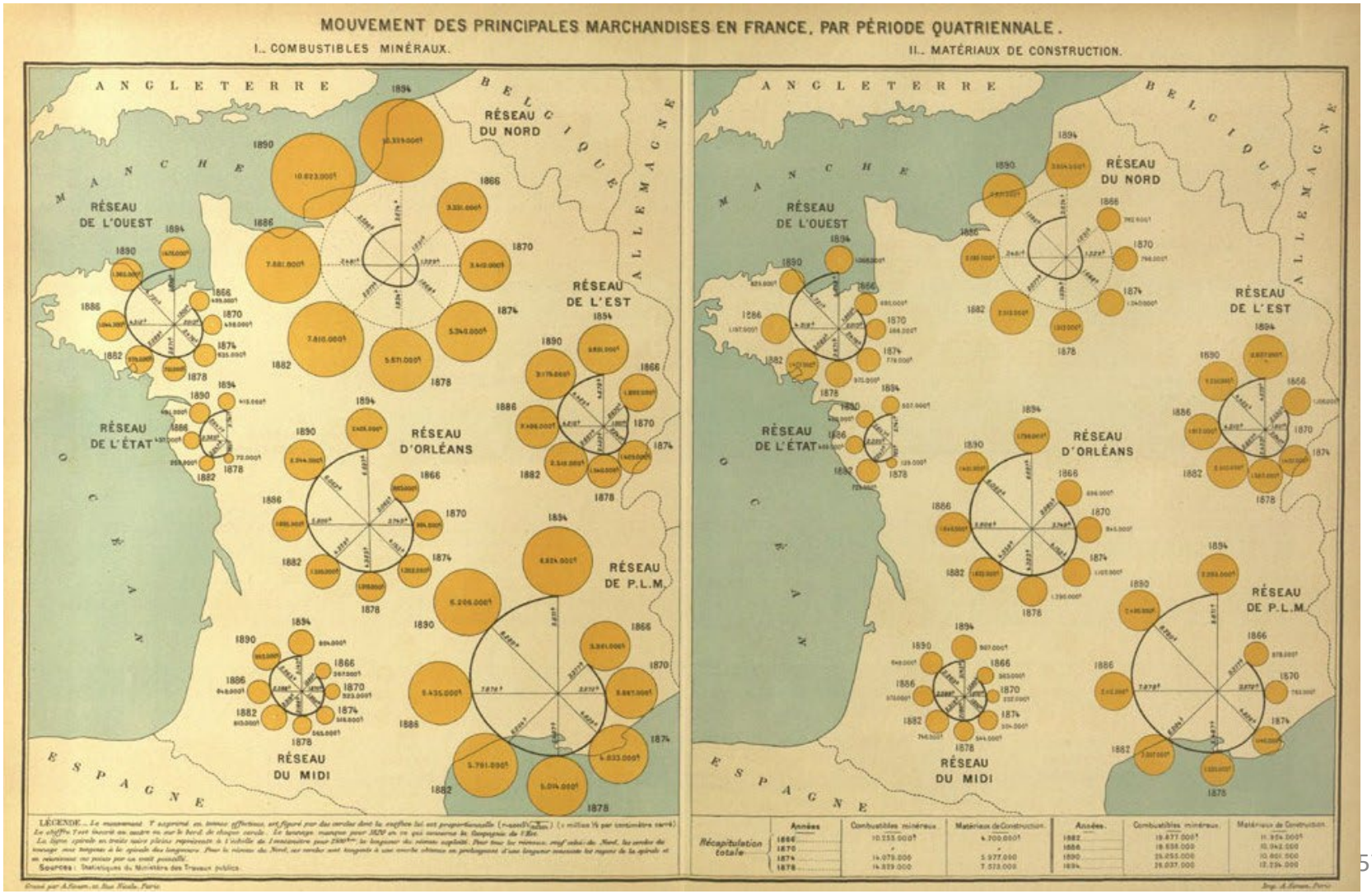
1889

Planetary diagrams

Movement of principal merchandise by region. Spiral ~ distance; circles ~ tonnage [Album, 1895, plate 9]

Combustible minerals

Construction materials



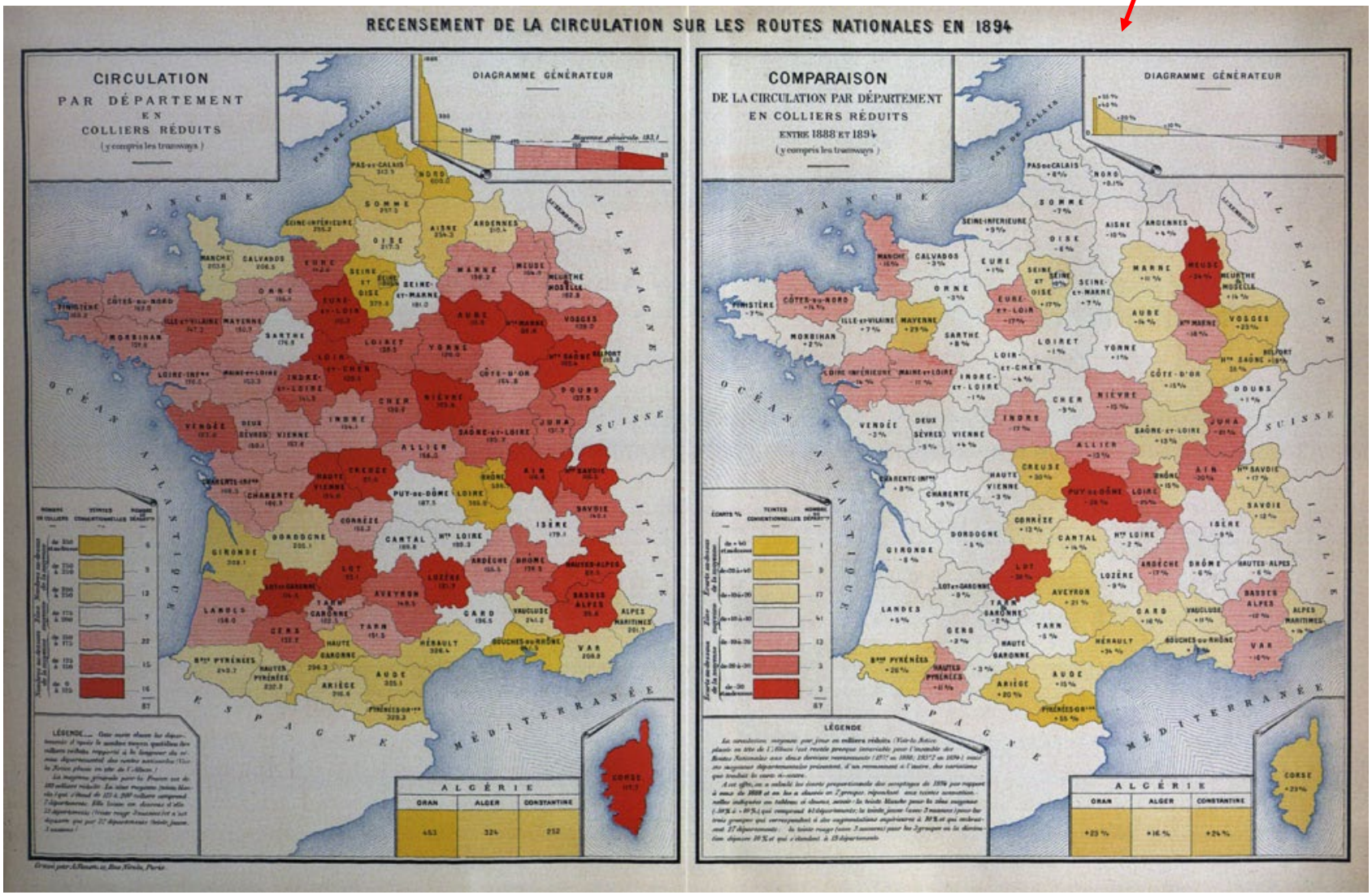
Classed choropleth maps,

- bipolar color scale
- visualizing change

Circulation on the national roads in ‘colliers réduits’, a standard measure

Left: 1894; Right: % change, 88-94

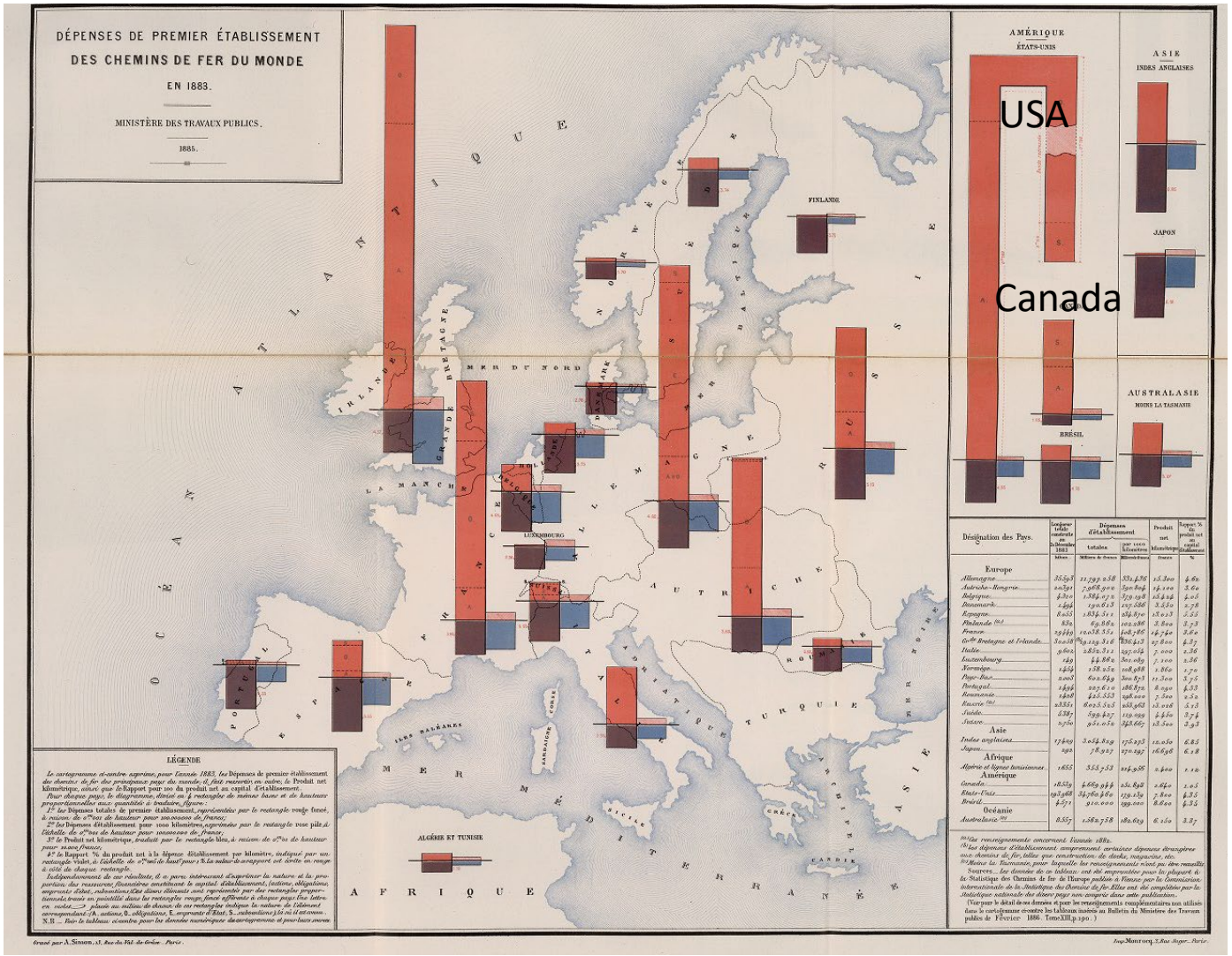
[Album, 1895, plate 21]

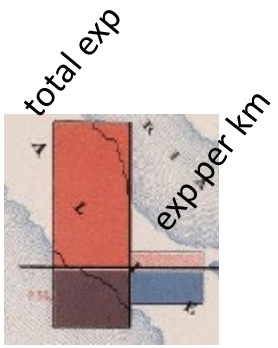


2x2 graphic bar charts

- 4 variables shown
- creative folding of long bars

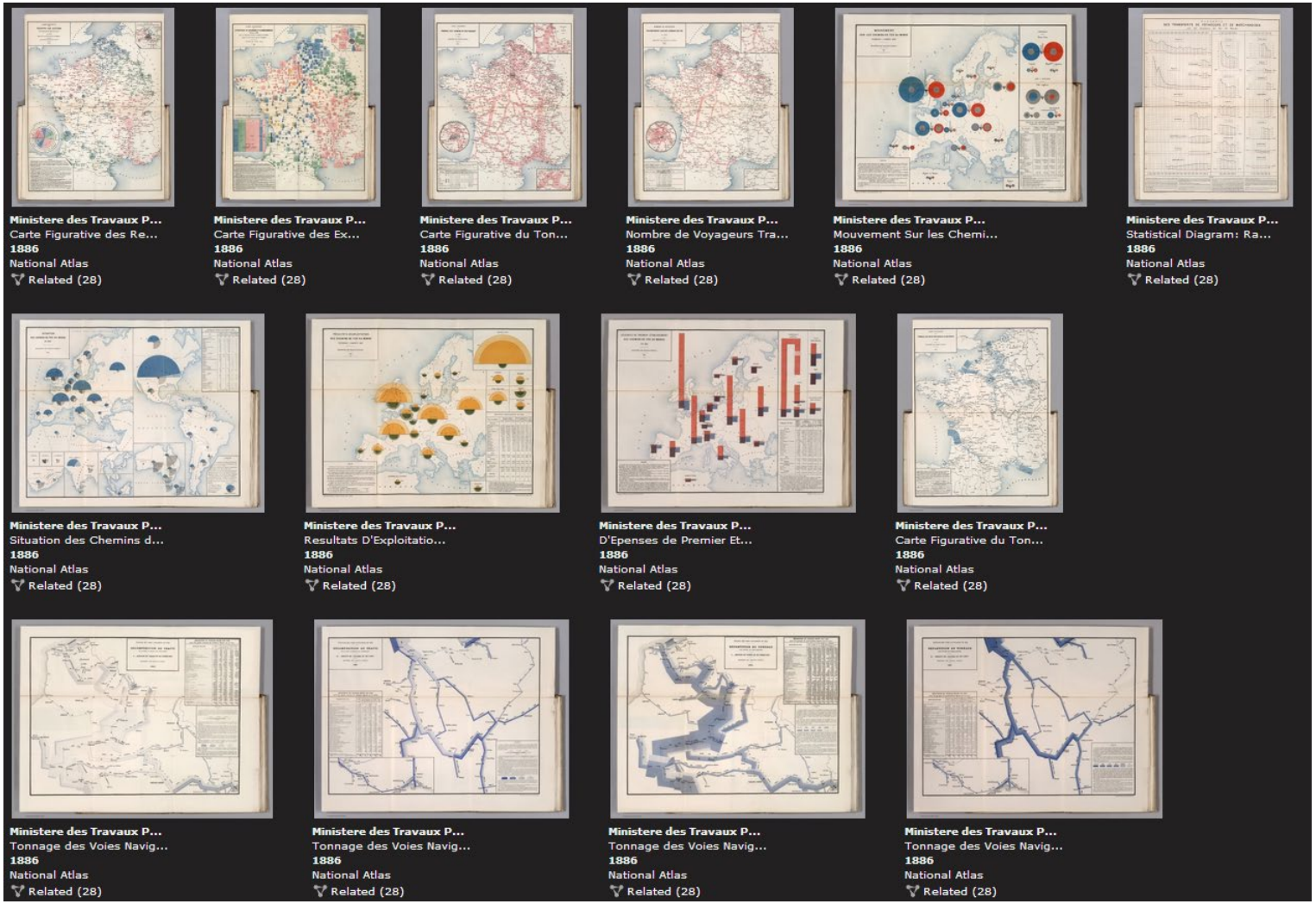
Expenses of the first establishment of railroads of the world as of 1883 [Album 1886, p. 11]





ASG now online: David Rumsey

All 18 volumes, https://www.davidrumsey.com/luna/servlet/s/nl72bu

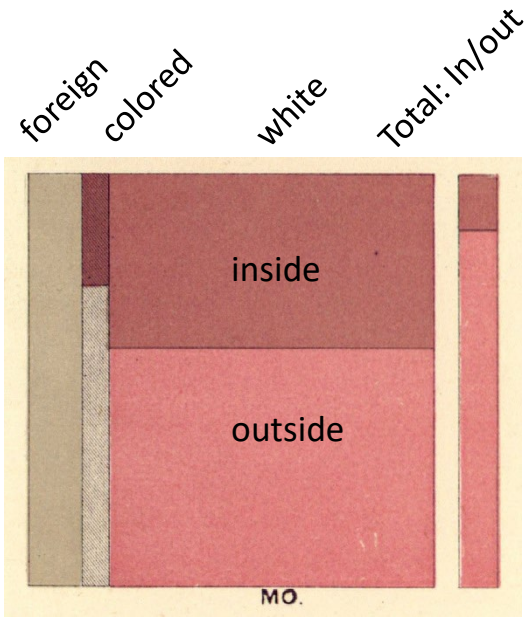


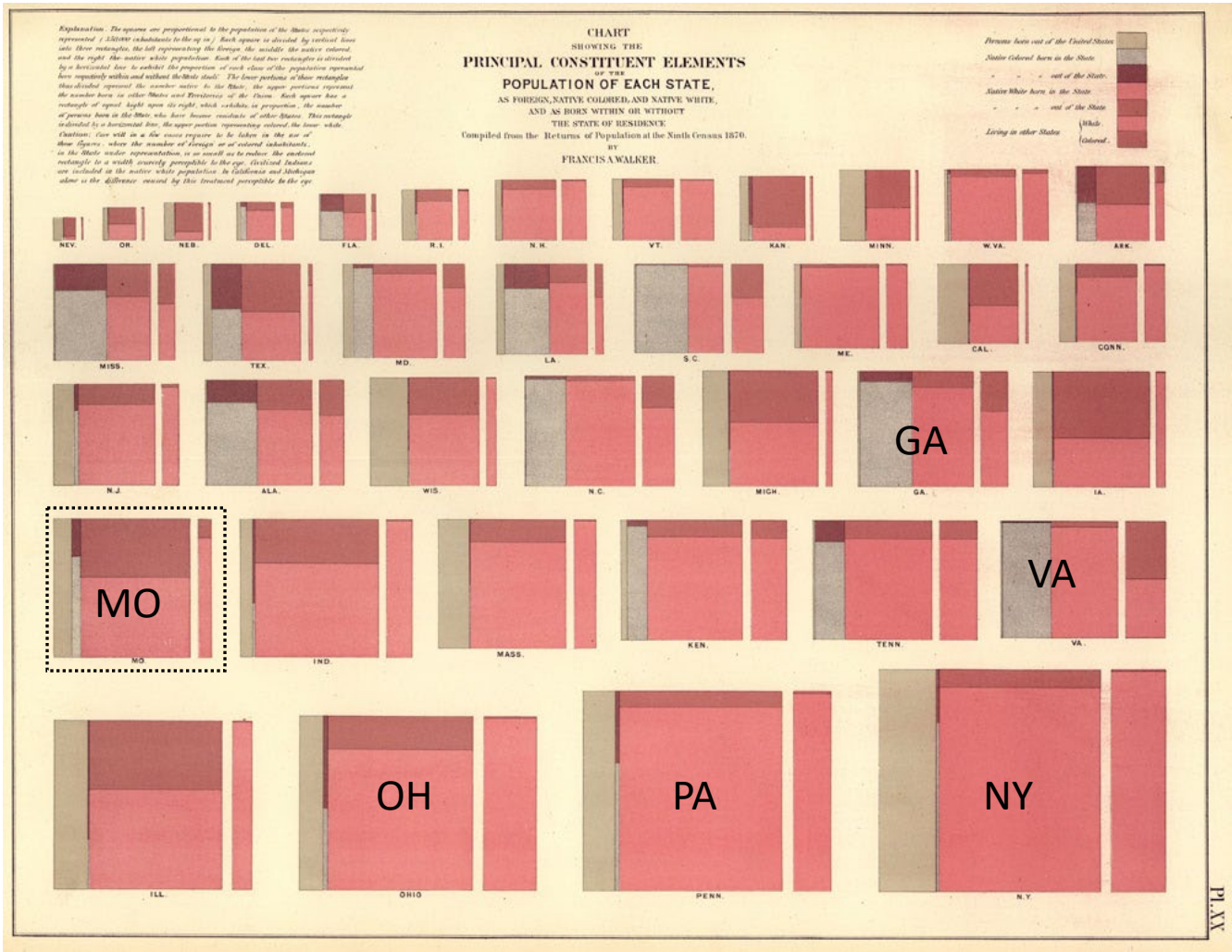
U.S. Census Atlases

- *Statistical Atlas of the Ninth Census* (1872) – Francis Walker
  - 60 plates: First graphic portrait of the nation
  - Topics: geology, minerals, weather, pop. by ethnicity, wealth, literacy, death rates by age, sex, cause, rates of blindness, insanity, etc.
- *Tenth Census* (1880) – Henry Gannett
  - 151 plates
- *Eleventh Census* (1890) – Henry Gannett
  - 126 plates

Mosaics/treemaps: Area ~ state population

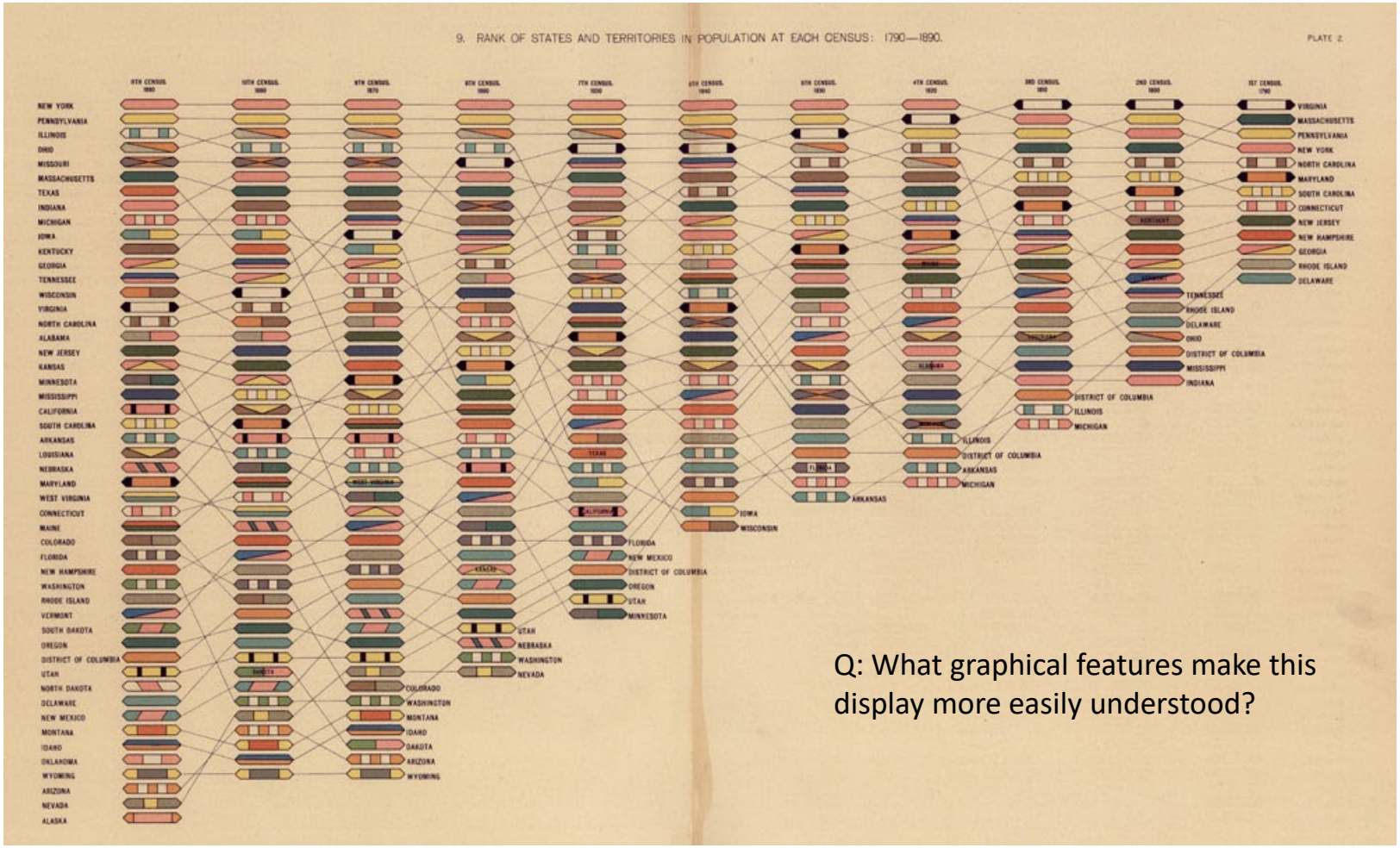
State populations: Foreign born / Native colored / White + Born inside/outside [Atlas, 1870, plate 20]





Linked parallel-coordinates time-series diagram

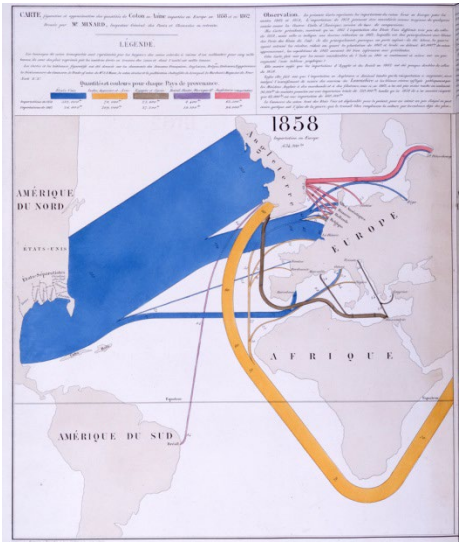
Rank of states & territories in each census, 1790—1890. [Atlas, 1898, plate 2]

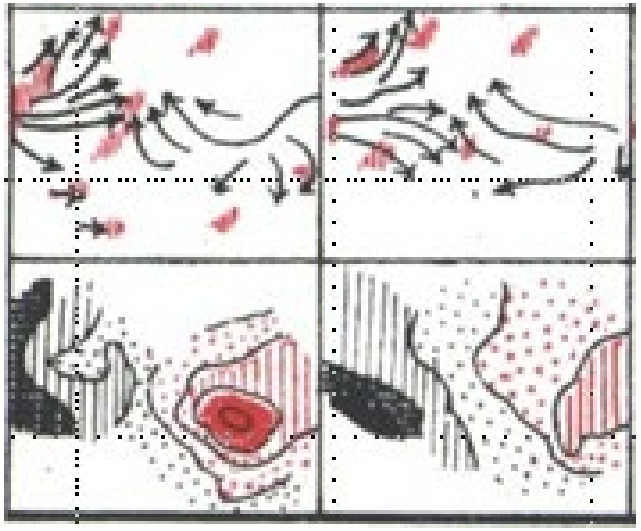


Q: What graphical features make this display more easily understood?

Golden Lessons

- What are the lessons for the future?
- Phenomena, not numbers or simply pretty pictures
  - Playfair, Guerry, Minard, Galton, etc. all developed new graphic forms to show **phenomena** of deep interest:
    - balance of trade, rates of crime, patterns in weather data, …
- **1st lesson**: data visualization today should have a similar focus





Golden Lessons: Graphical Impact

- Impact: Early ideas
  - Playfair, Guerry: data should “speak to the eyes”
  - Minard, Lalanne: allow “calculation by the eyes”
  - Nightingale: graphs should speak to the heart and mind, influence public policy & practice
- Graphical impact (Tukey, 1990)
  - Interocularity: the message hits you between the eyes
  - Immediacy: it hits you fast
  - Inescapability: it is hard to avoid the message
- **2nd lesson**: strive for visual impact in graphs and tables

Golden Lessons: Expressive power

- Hand-made graphics were often beautiful but entailed much sweat and hard work.
- Today: software– ease of use vs. expressive power
- Theories of graphics → graphic "languages"
  - Bertin: *Semiology of graphics*
  - Wilkinson: *Grammar of Graphics*
    - Wickham: *ggplot2* R package
  - In all: the devil is in the details!
- **3rd lesson**: continue to reduce the distance between a graphic idea and appearance on screen or paper.

Conclusions

The only new thing… is the history you don't know **– Harry Truman**

- Data visualization has deep roots:
  - Cartography
  - Statistical theory
  - Data collection
  - Visual thinking
  - Technology

  All combine to give insightful views of data

  Each area fed from, and nourished the others

- The Golden Age:
  - Qualitatively distinct, deserves recognition
  - Works of unparalleled beauty & scope
  - Statistical graphics had a ***purpose***: tell a story, inform decision
  - Provides lessons for today and tomorrow