

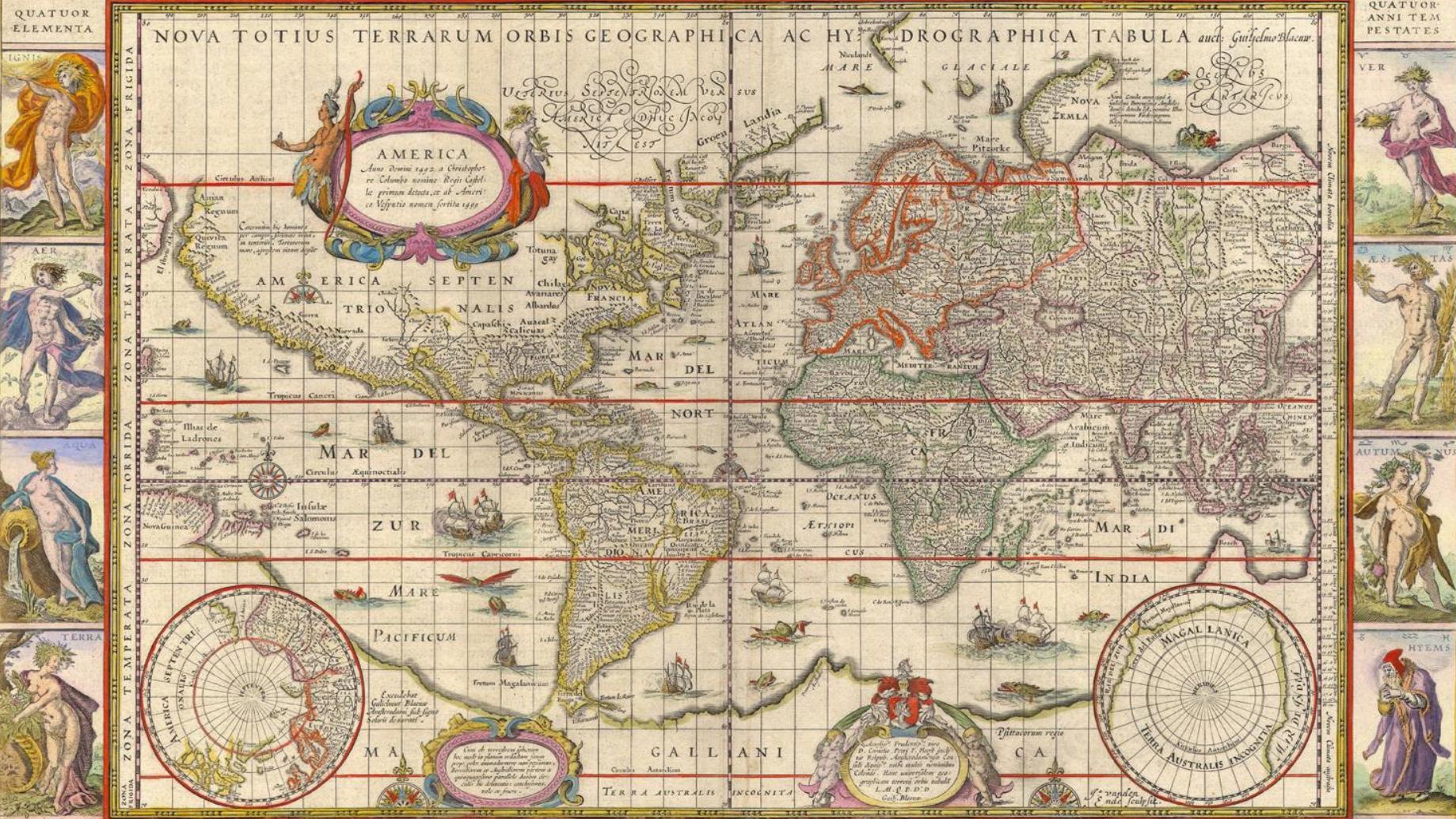
Classic Examples in Data Visualization

Stat 133 with Gaston Sanchez

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A bit of history

Using graphics to
represent numerical
information?

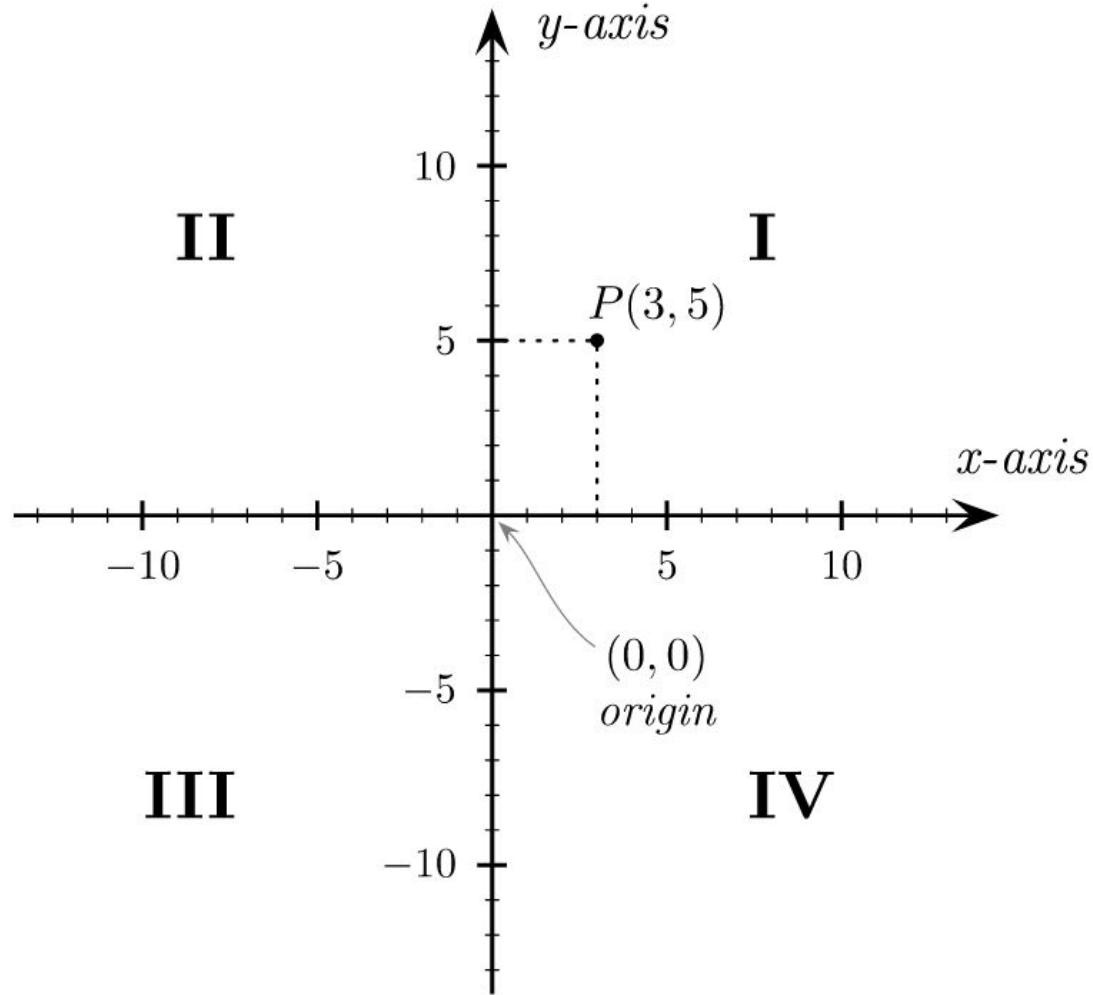




René Descartes
(1596 - 1650)
French Philosopher and
Mathematician

Inventor of “cartesian” system

Cartesian coordinates

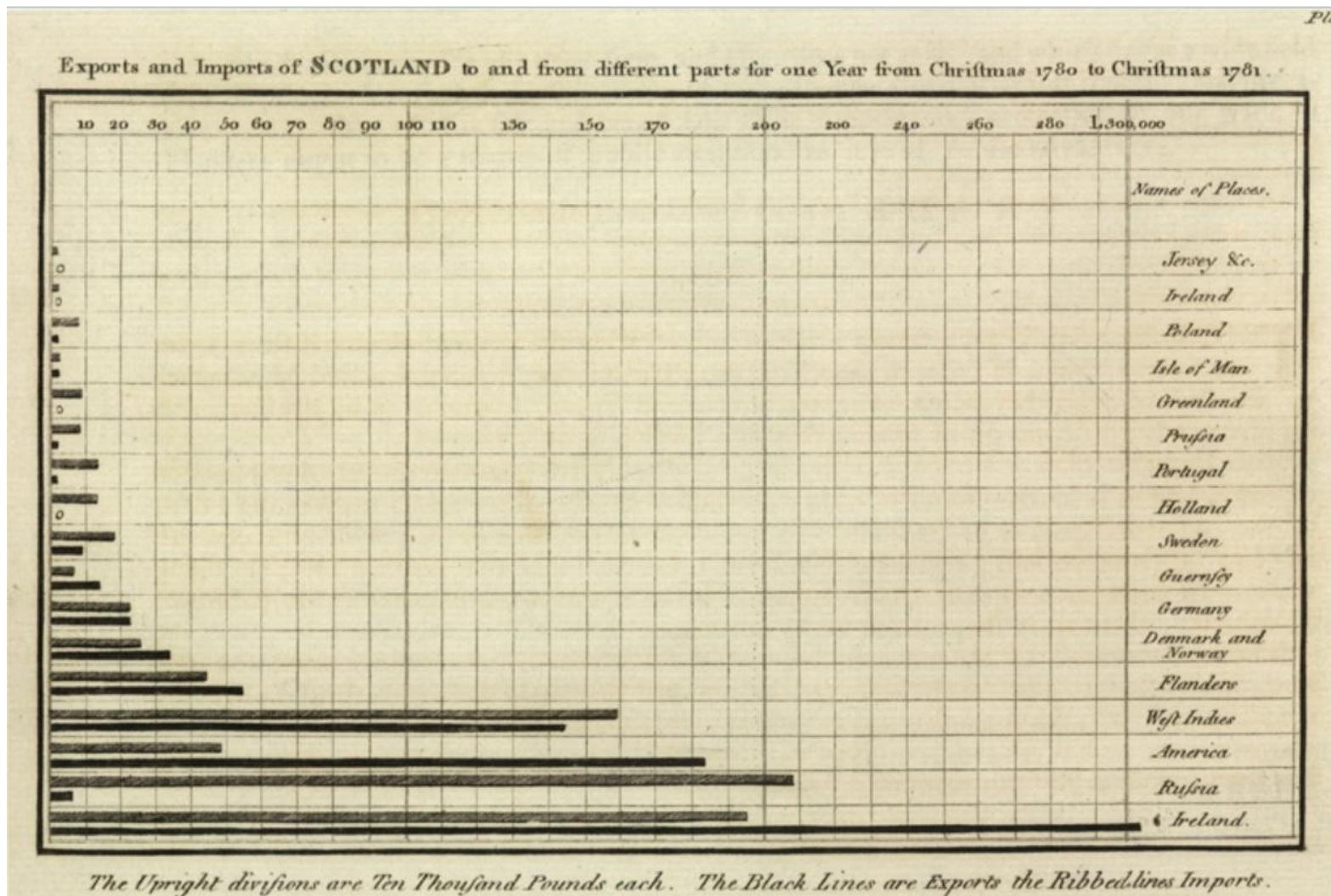




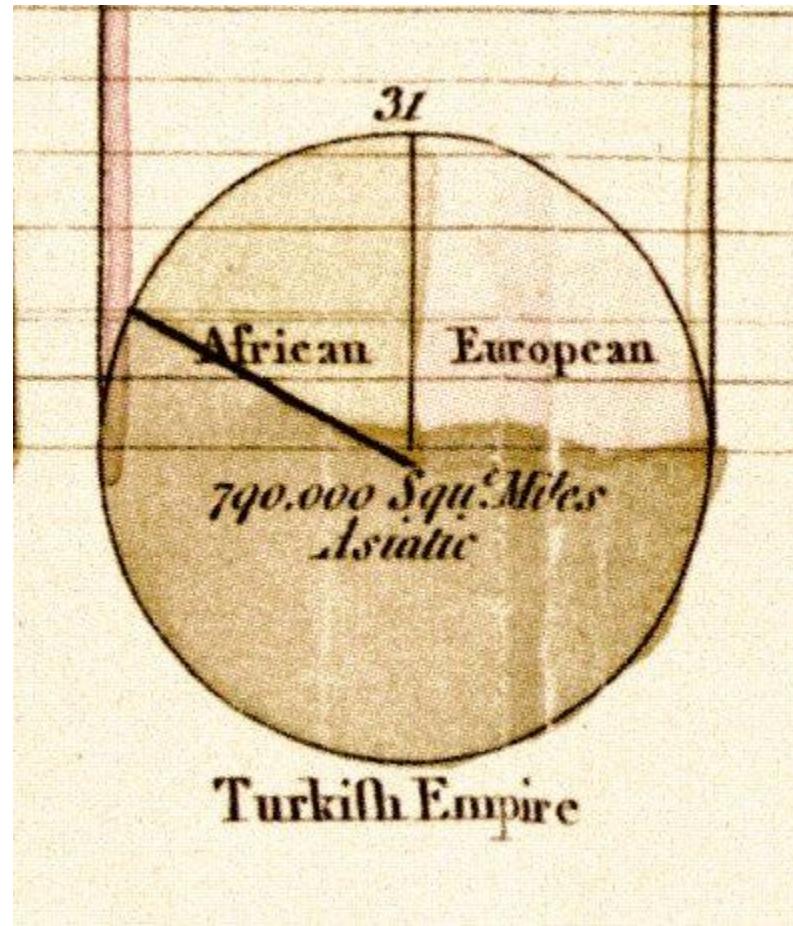
William Playfair
(1759 - 1823)
Scottish Social Scientist

Inventor of bar-charts, pie-charts, line-charts

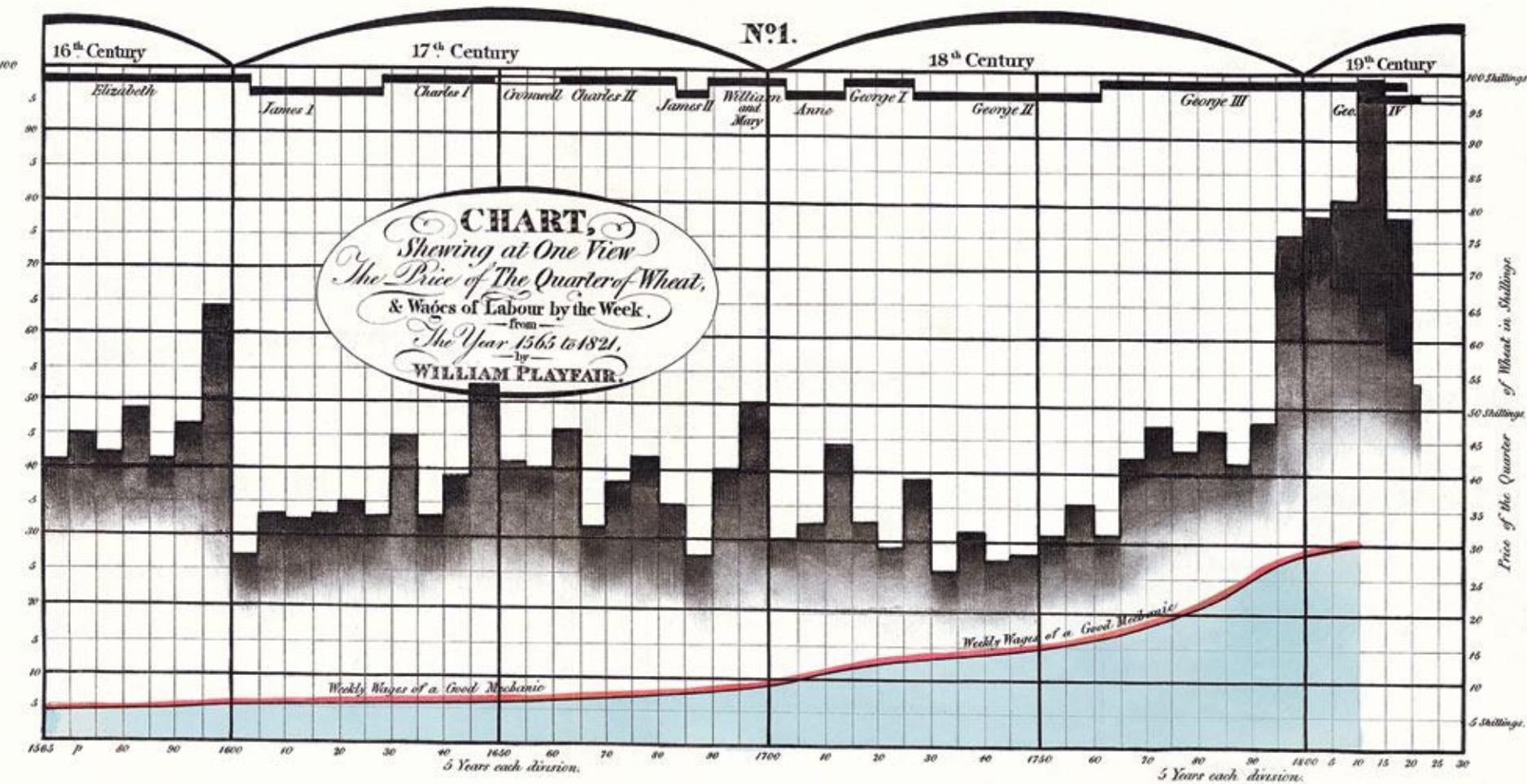
Playfair's bar-chart



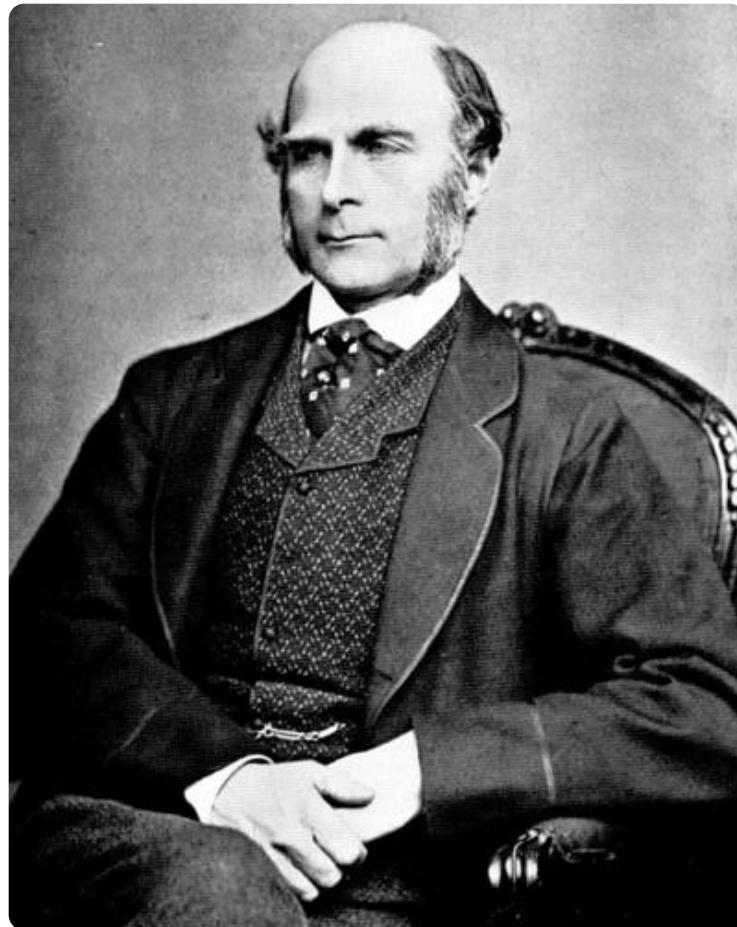
Playfair's pie-chart



Playfair's chart



Francis Galton (1822-1911)



Galton's motto: *Count wherever you can*

ANTHROPOLOGICAL MISCELLANEA.

1886

REGRESSION *towards MEDIOCRITY in HEREDITARY STATURE.*

By FRANCIS GALTON, F.R.S., &c.

[WITH PLATES IX AND X.]

THIS memoir contains the data upon which the remarks on the Law of Regression were founded, that I made in my Presidential Address to Section H, at Aberdeen. That address, which will appear in due course in the Journal of the British Association, has already been published in "Nature," September 24th. I reproduce here

Galton Data Set

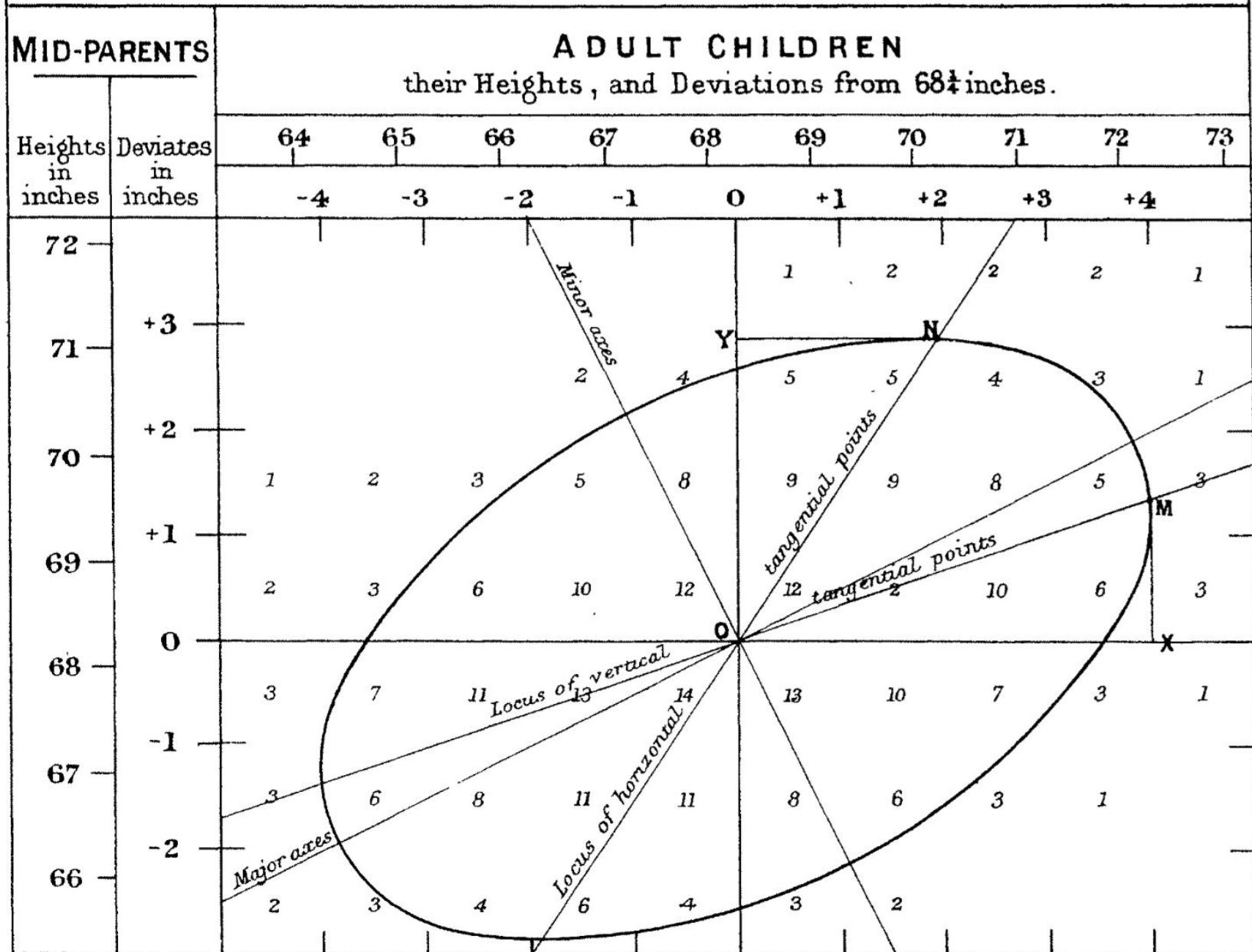
Height data:

- 205 pairs of parents
- 928 adult children

Scatter plot:

- X-axis: height of adult children
- Y-axis: height of mid-parent

DIAGRAM BASED ON TABLE I.
 (all female heights are multiplied by 1.08)





John Tukey
(1915 - 2000)
American Mathematician

*Promoter of Exploratory Data Analysis
Inventor of box-plots, stem-and-leaf plots, etc*

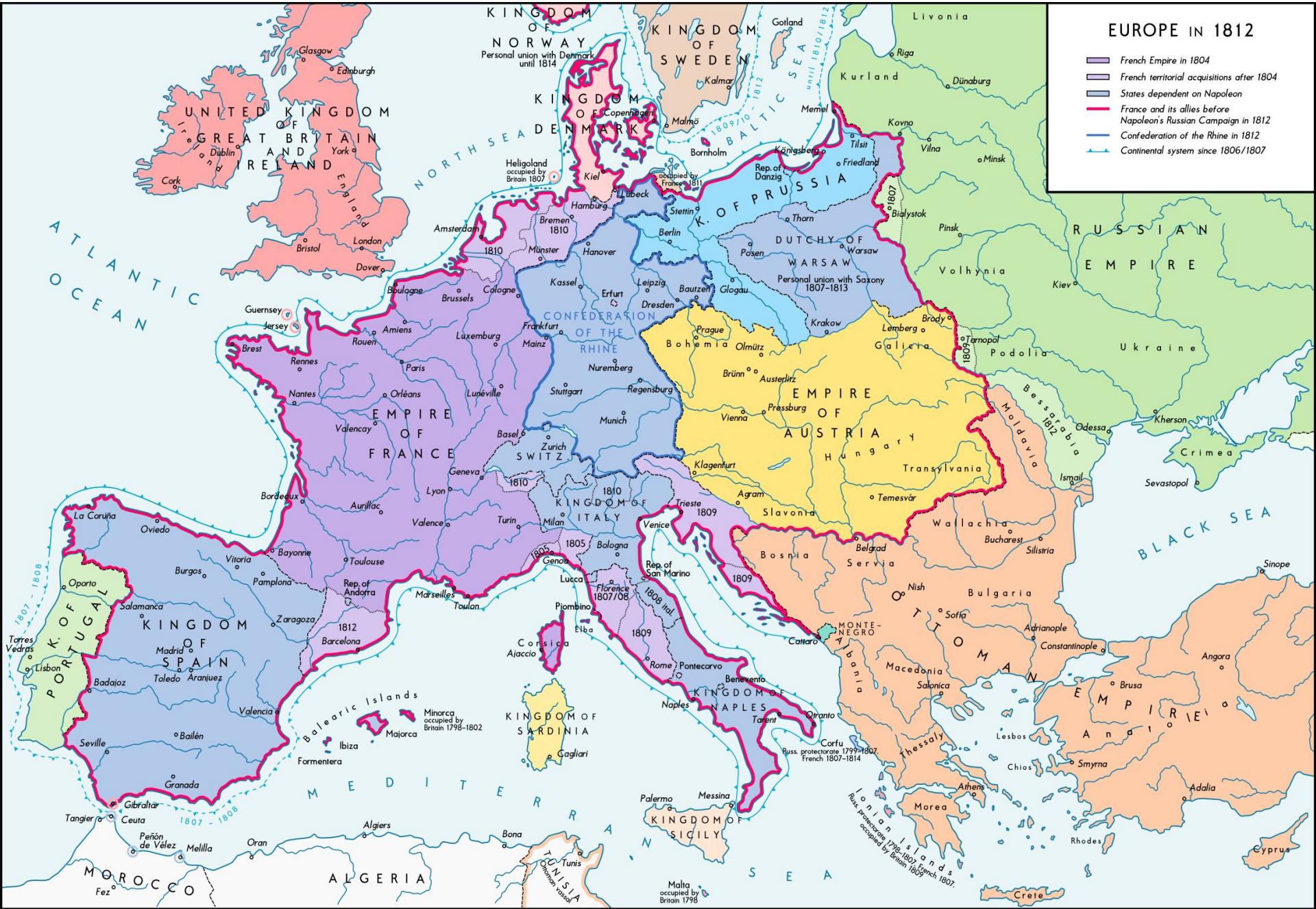
A classic example



"Napoleon Crossing the Alps" by Jacques Louis David. The horse is believed to be Marengo.

EUROPE IN 1812

- French Empire in 1804
- French territorial acquisitions after 1804
- States dependent on Napoleon
- France and its allies before Napoleon's Russian Campaign in 1812
- Confederation of the Rhine in 1812
- Continental system since 1806/1807



Some Historical Background

1776 Declaration of Independence (USA)

1786 French Revolution

1792 French First Republic

1804 French First Empire

Napoleon becomes Emperor

1803 - 1815 Napoleonic Wars

1812 War between US and United Kingdom

French Invasion of Russia

“Russian Campaign”

June 1812

Grande Armée
(~500,000 men)



Charles Joseph Minard
(1781 - 1870)
French Civil Engineer

Created very novel and sophisticated graphics

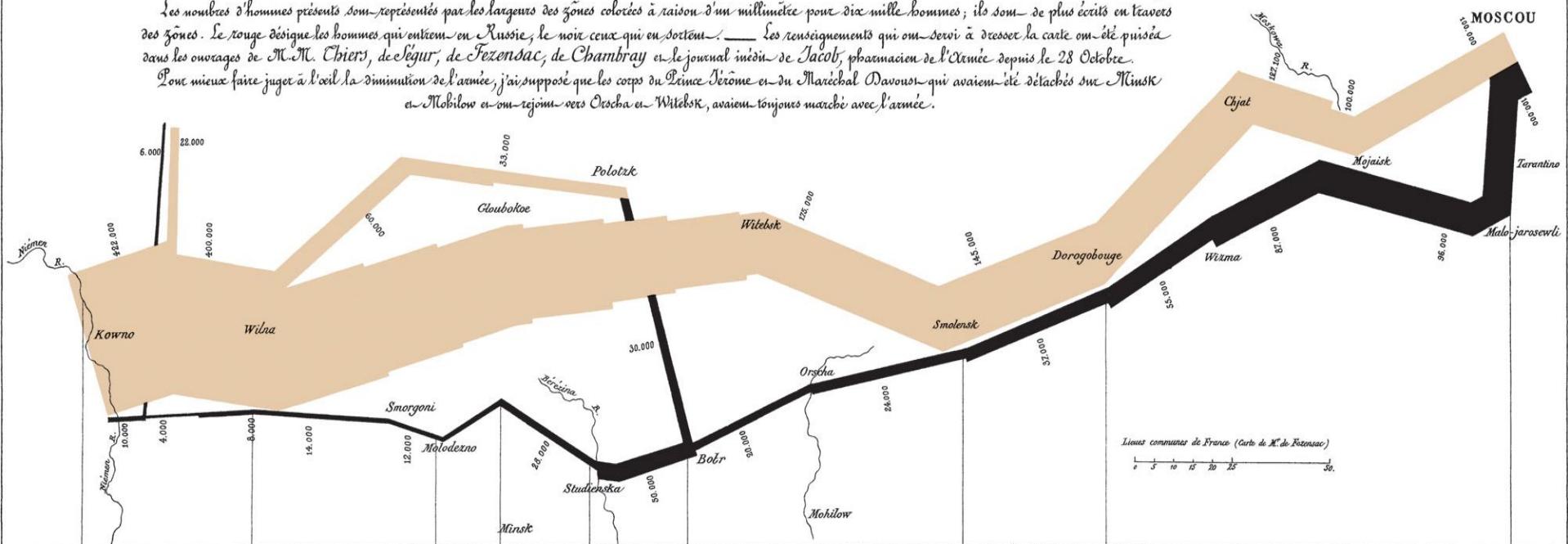
Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812-1813 (made in 1869)

Carte Figurative des pertes successives en hommes de l'Armée Française dans la Campagne de Russie 1812-1813.
Dessinée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.

Paris, le 20 Novembre 1869.

Les nombres d'hommes présents sont représentés par les larges des zones colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zones. Le rouge désigne les hommes qui entrent en Russie; le noir ceux qui en sortent. Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de M. M. Chiers, de Segur, de Fezensac, de Chambray et le journal intérieur de Jarol, pharmacien de l'Armée depuis le 28 Octobre.

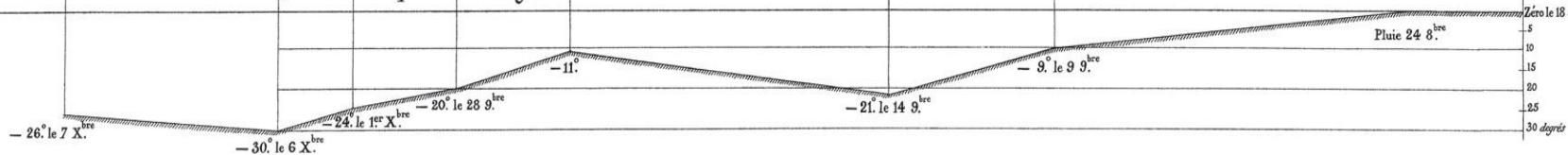
Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout, qui avaient été détachés sur Minsk et Mohilow et se rejoignaient vers Orscha et Witebsk, avaient toujours marché avec l'armée.



Lieux communs de France (Carte de M. de Fezensac)

0 5 10 15 20 25 30

TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



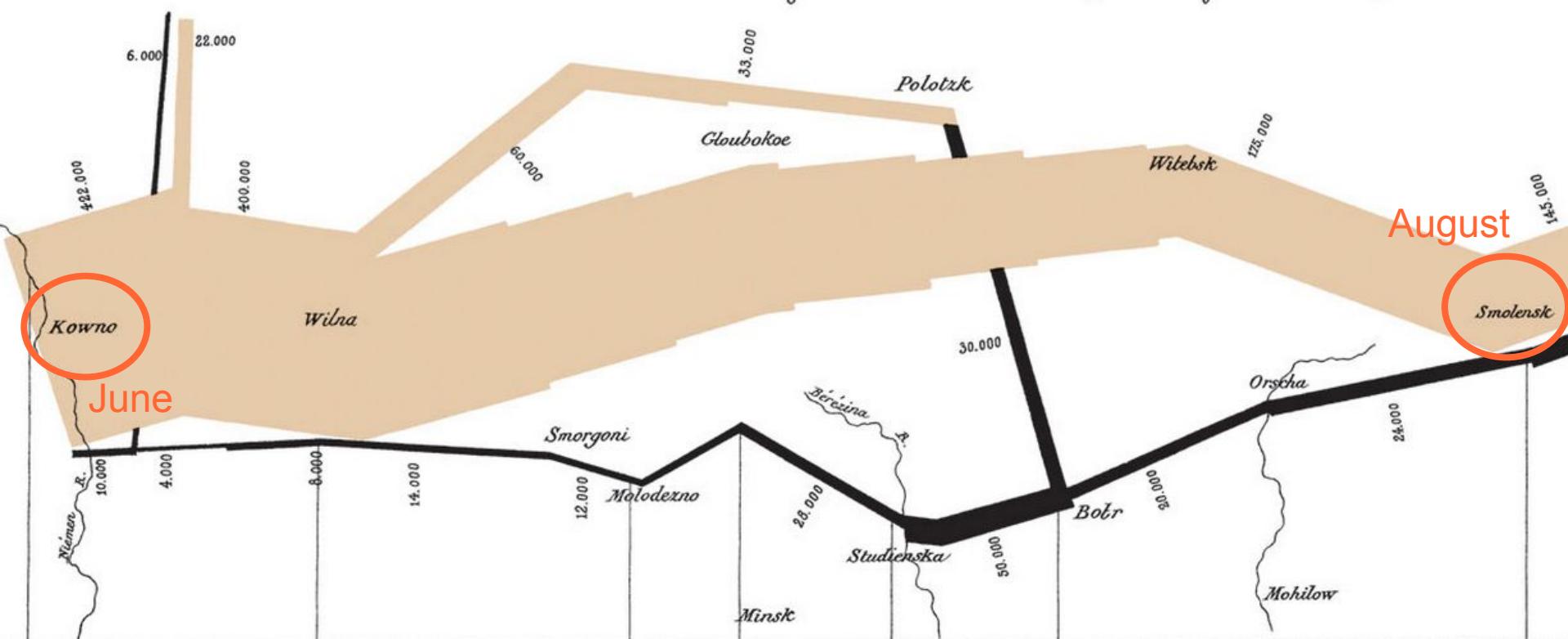
Les Cosaques passent au galop
le Niemen gelé.

7 variables in one chart

1. Number of troops
2. Traveled distance
3. Temperature
4. Latitude
5. Longitude
6. Direction of travel
7. Location relative to specific dates

Lans,

Les nombres d'hommes présents sont représentés par les largeurs des zones colorées à raison d'un millimètre pour dix mille hommes; ilo
des zones. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à d
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Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davout qui avaient
en Mohilow se sont rejoints vers Orscha et Wilebsk, avaient toujours marché avec l'armée.

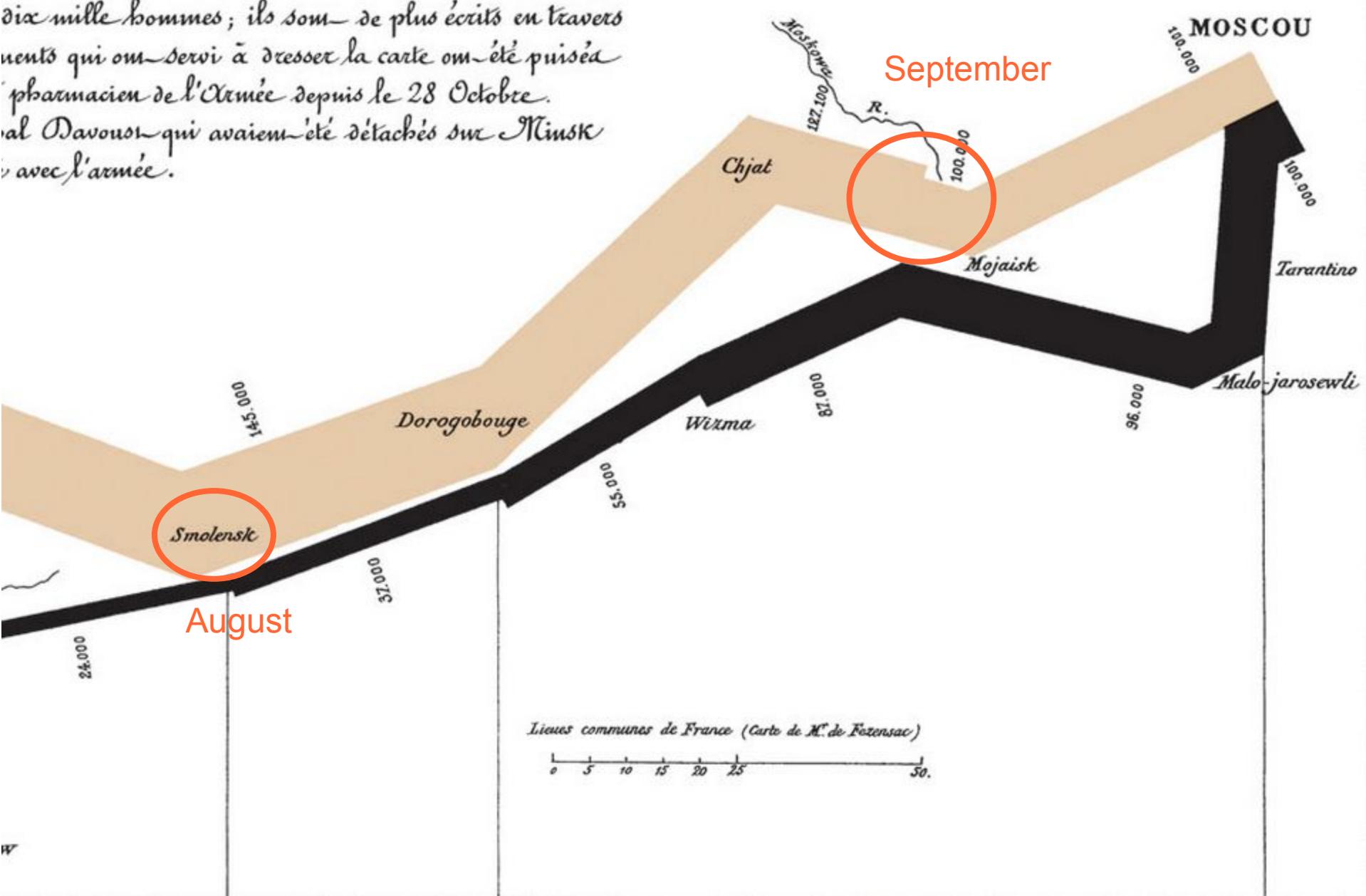




Russian Army
evacuating Smolensk

L'aris, le 20 Novembre 1869.

dix mille hommes ; ils sont de plus écrits en travers
nents qui ont servi à dresser la carte ont été puisés à
pharmacien de l'Armée depuis le 28 Octobre.
al Davout qui avaient été détachés sur Minsk
avec l'armée.



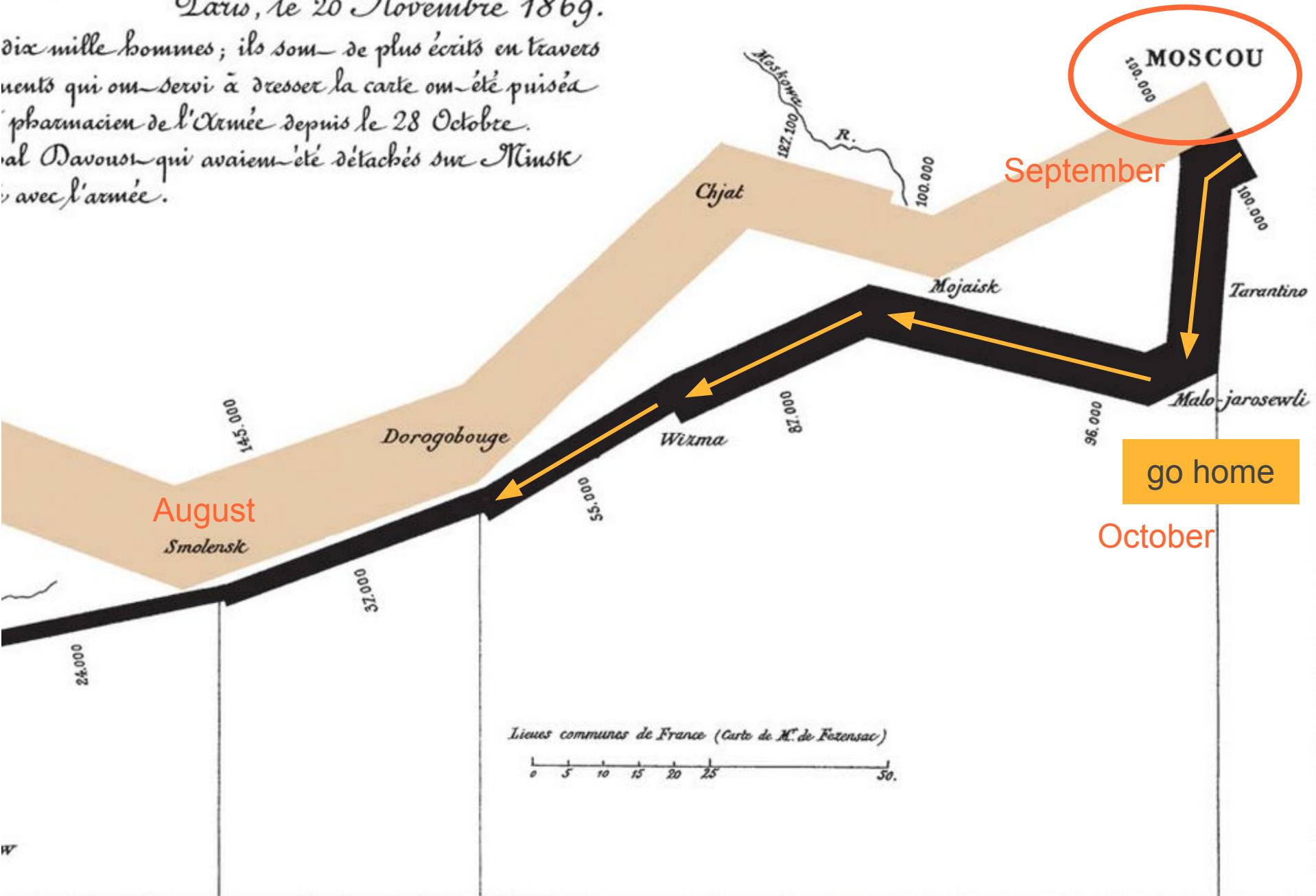
Capture of Moscow
September 1812
~100,000 men



Burning of Moscow

Paris, le 20 Novembre 1869.

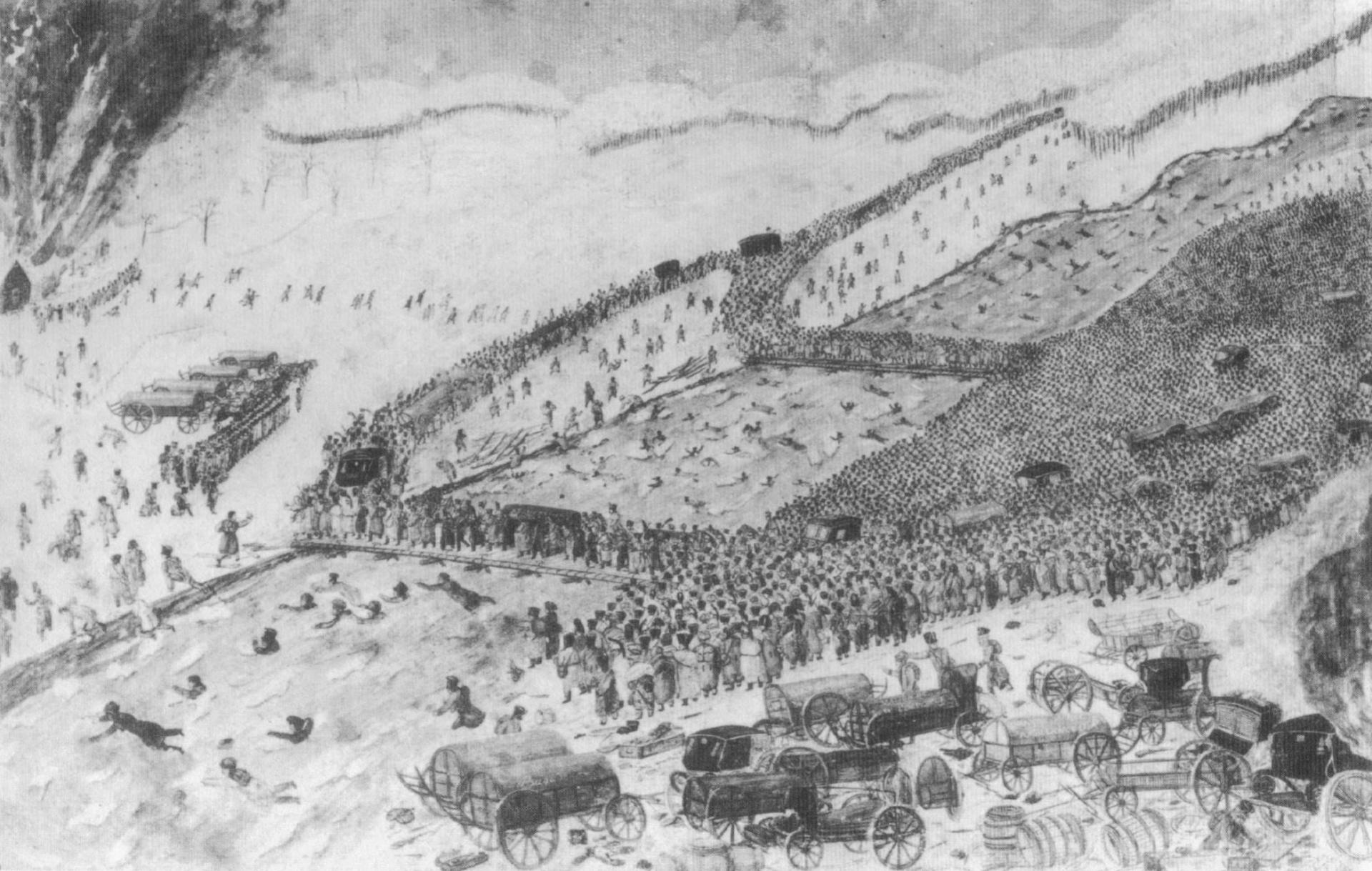
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La retraite de Russie

The Berezina crossing



Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812-1813

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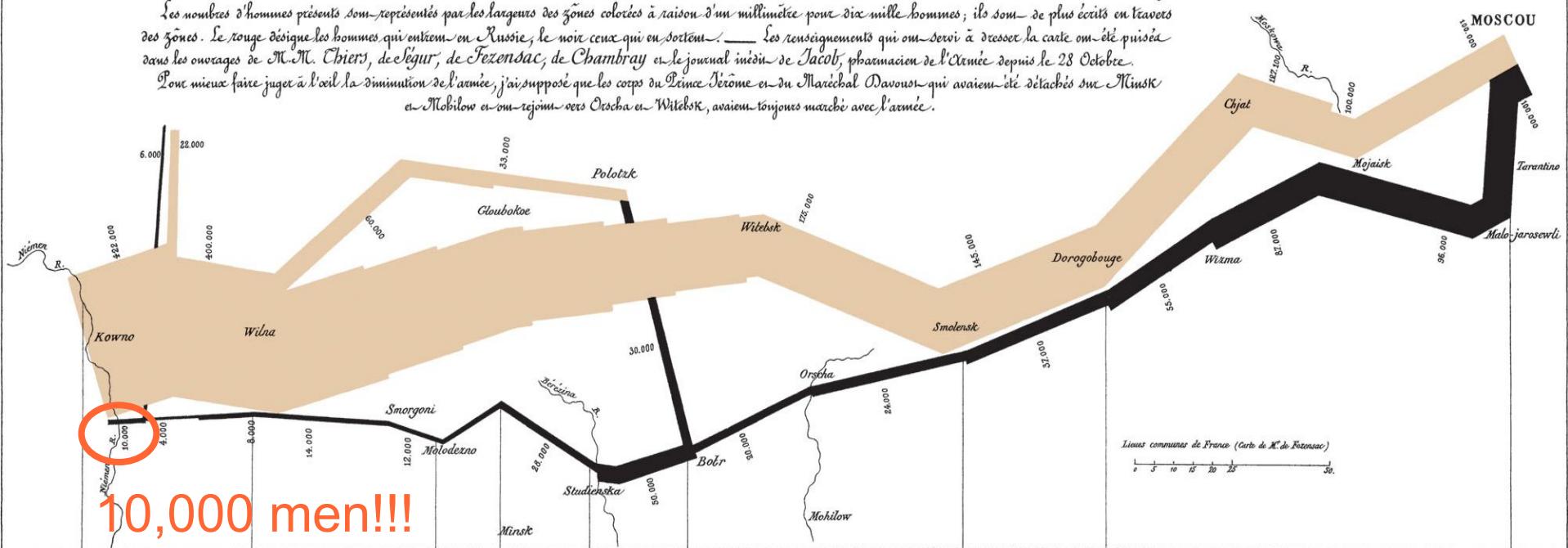
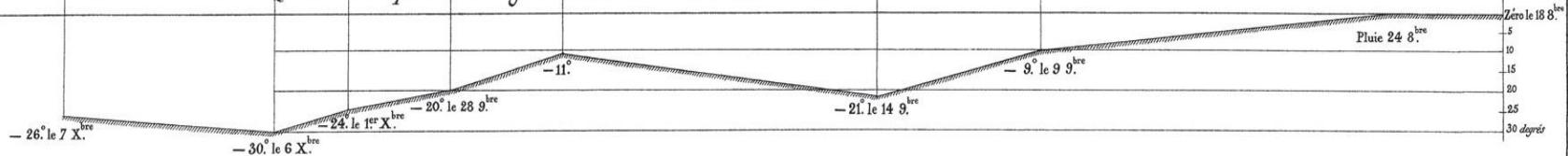


TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.



Another classic
example

30+ years ago...

Jan-28-1986



Some Remarks

- Space Race
- Cold War
- Many delays
- First civilian as part of the crew
- Reagan's “State of the Union”
planned the same day

A major malfunction

Challenger's brief flight

.678 seconds

Following Challenger's liftoff, a puff of black smoke — seen only by automatic launch cameras — indicates a problem with one of the O-ring seals at the joint between segments of the shuttle's right-hand solid rocket booster.

No human eyes see the smoke, and there would have been no way to abort the flight if they had.

58 seconds

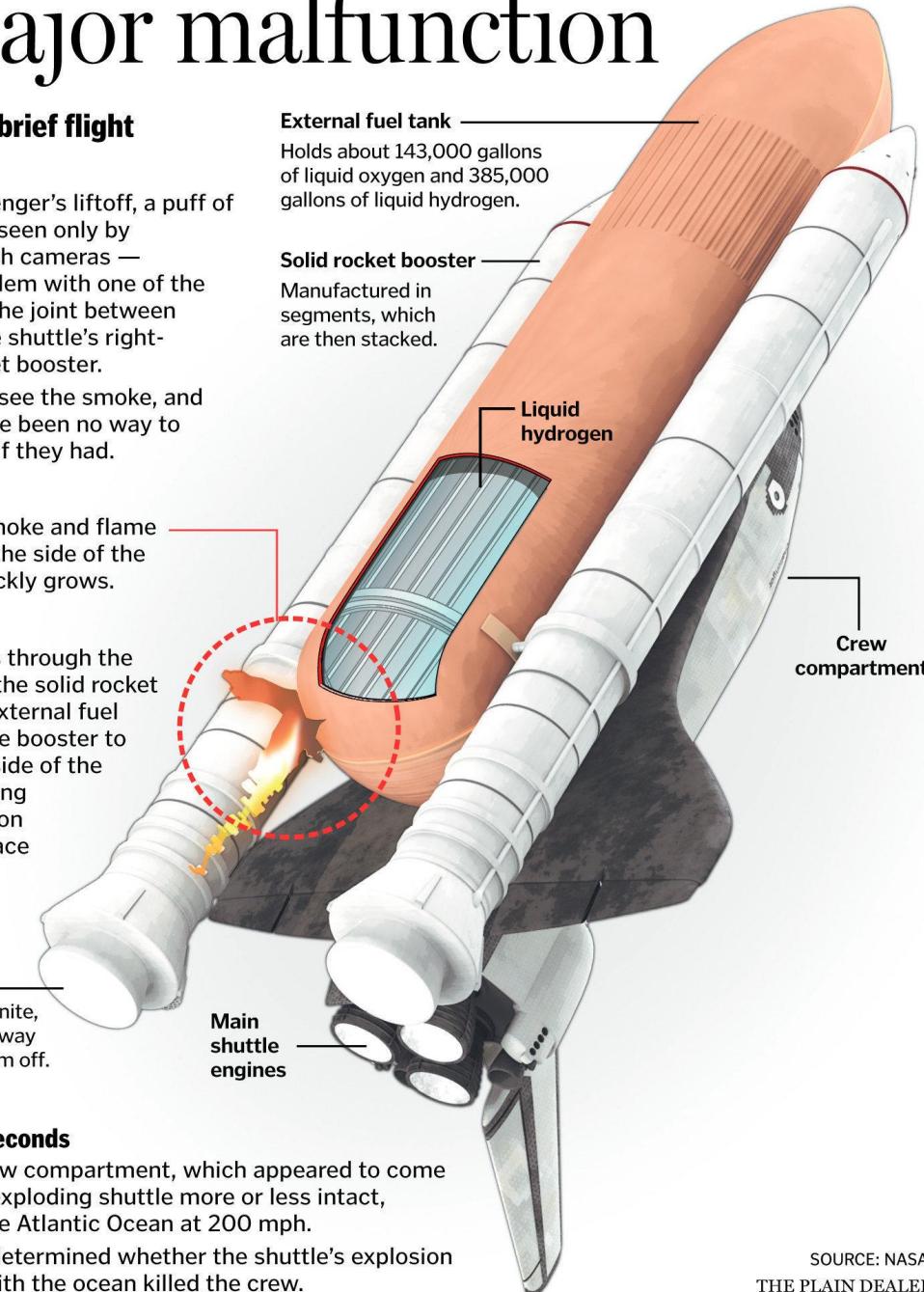
A small jet of smoke and flame bursts through the side of the booster and quickly grows.

73 seconds

The flame burns through the strut attaching the solid rocket booster to the external fuel tank, causing the booster to swivel into the side of the tank. The resulting massive explosion destroys the space shuttle.

Full thrust

Once the boosters ignite, there is no way to shut them off.



3 minutes, 58 seconds

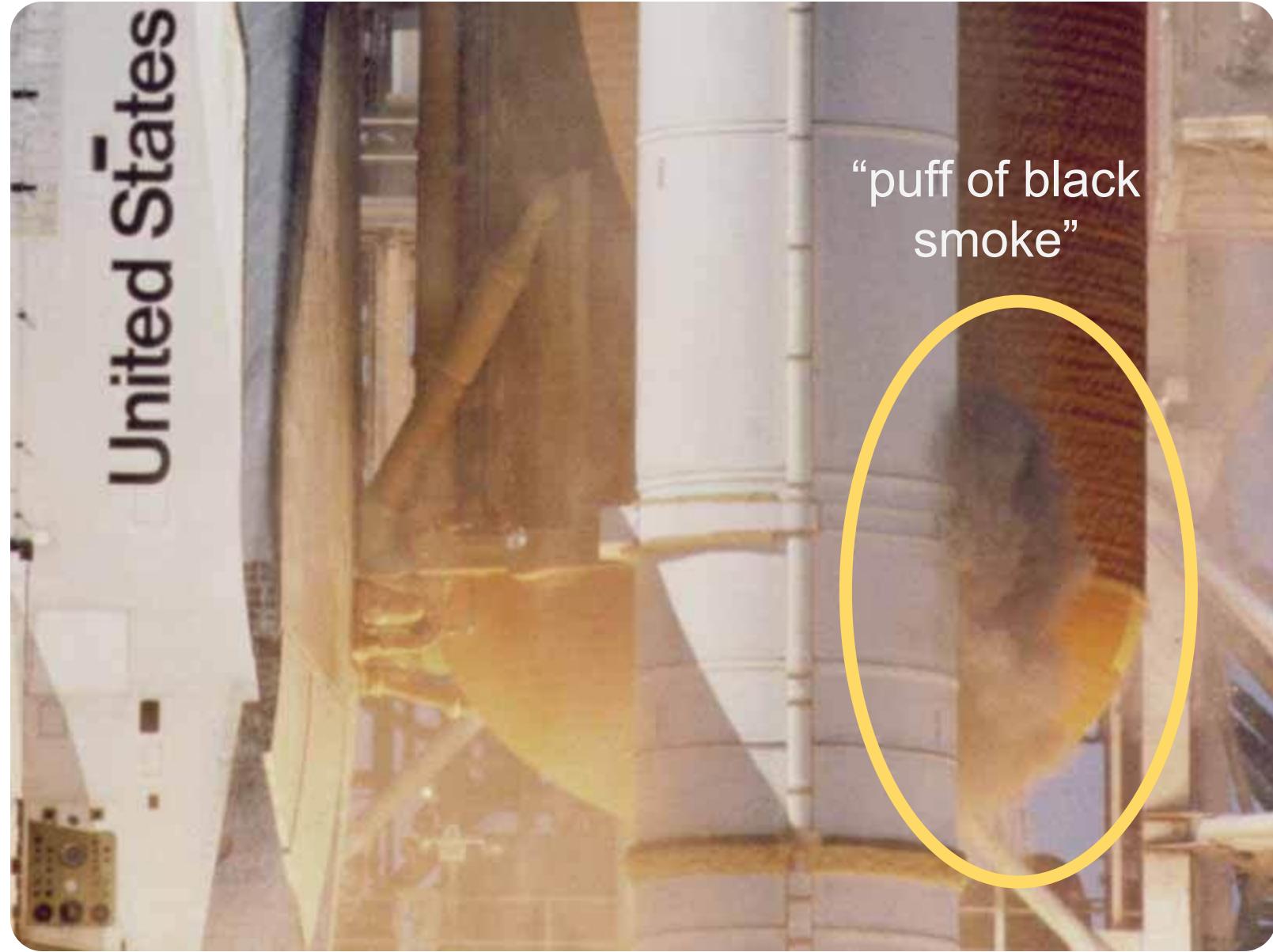
Challenger's crew compartment, which appeared to come away from the exploding shuttle more or less intact, smashes into the Atlantic Ocean at 200 mph.

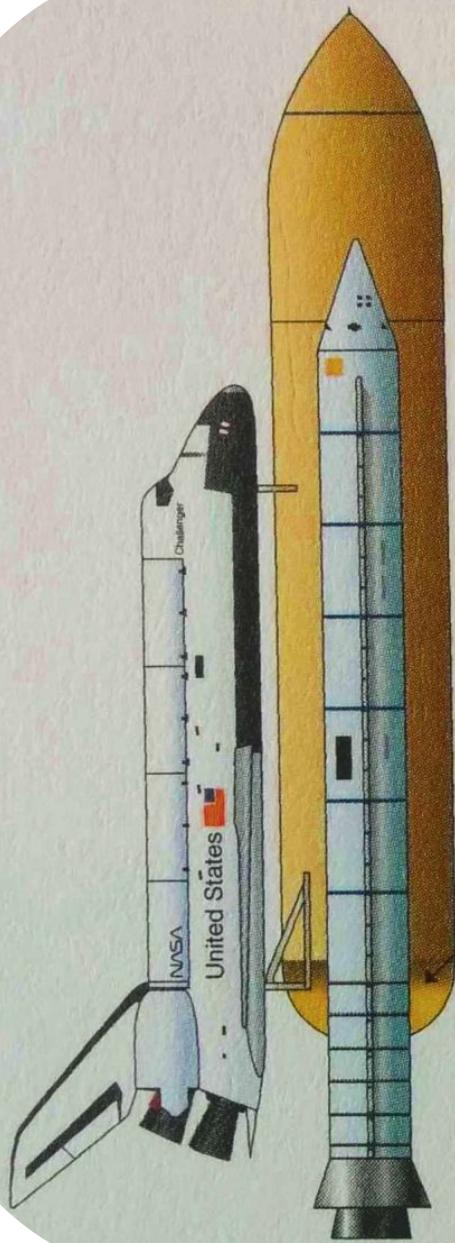
Officials never determined whether the shuttle's explosion or the impact with the ocean killed the crew.

SOURCE: NASA
THE PLAIN DEALER

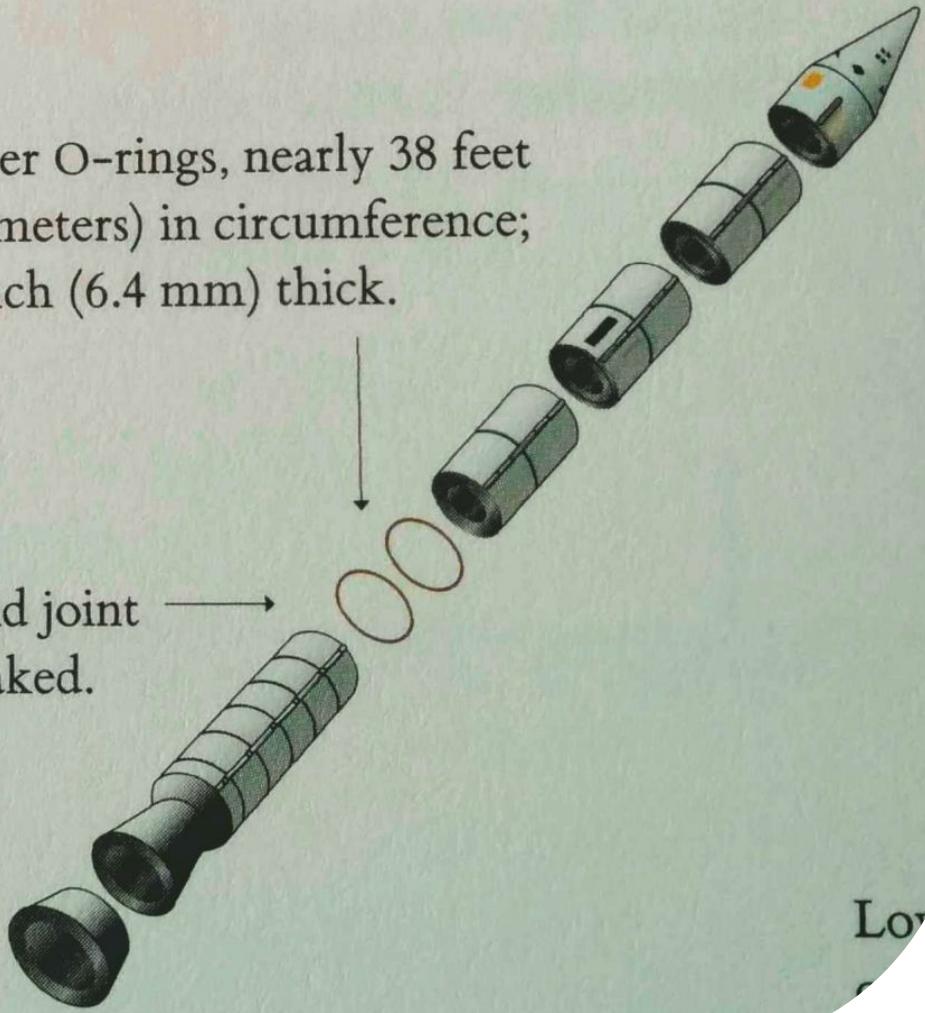
United States

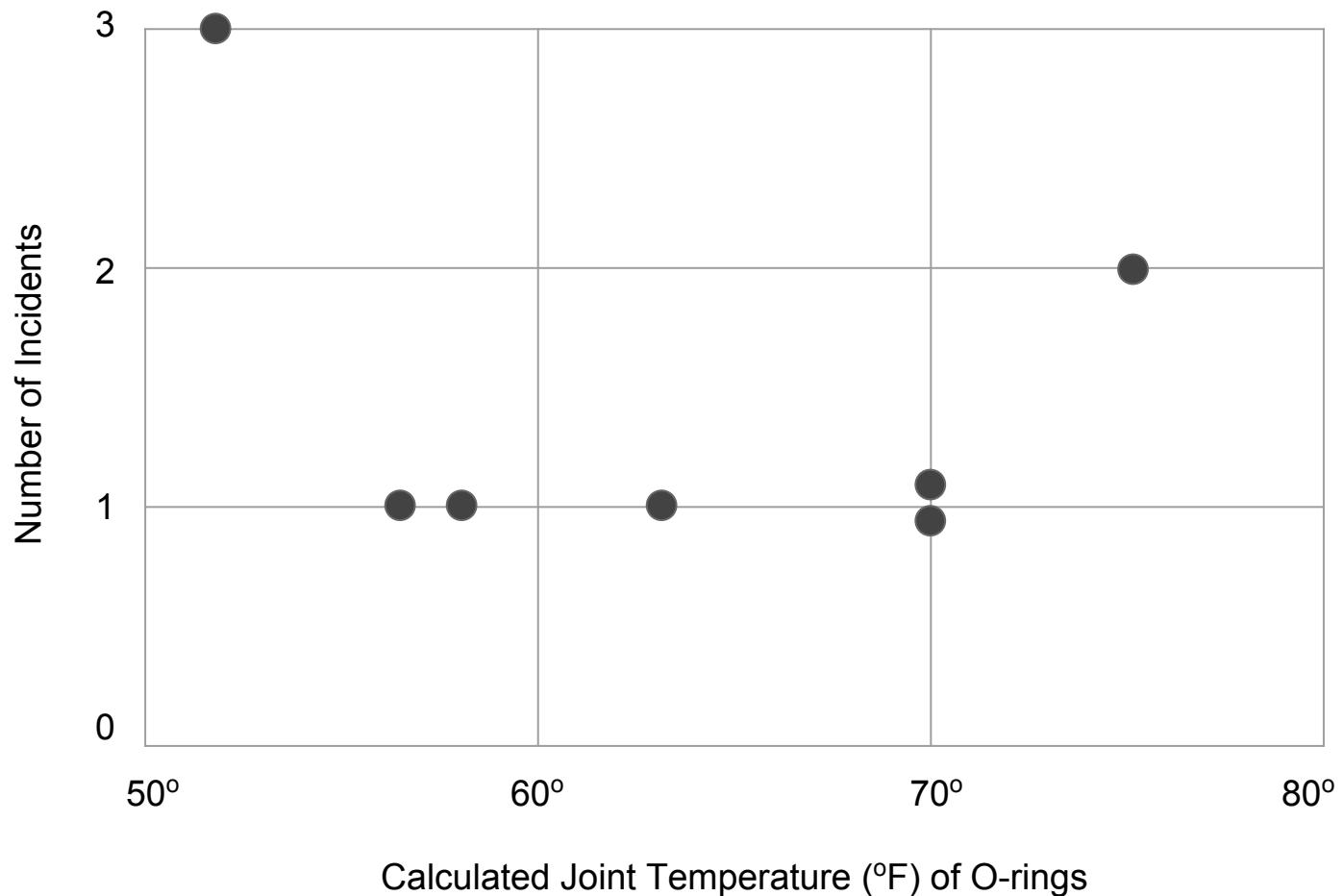
“puff of black
smoke”





Rubber O-rings, nearly 38 feet
(11.6 meters) in circumference;
1/4 inch (6.4 mm) thick.

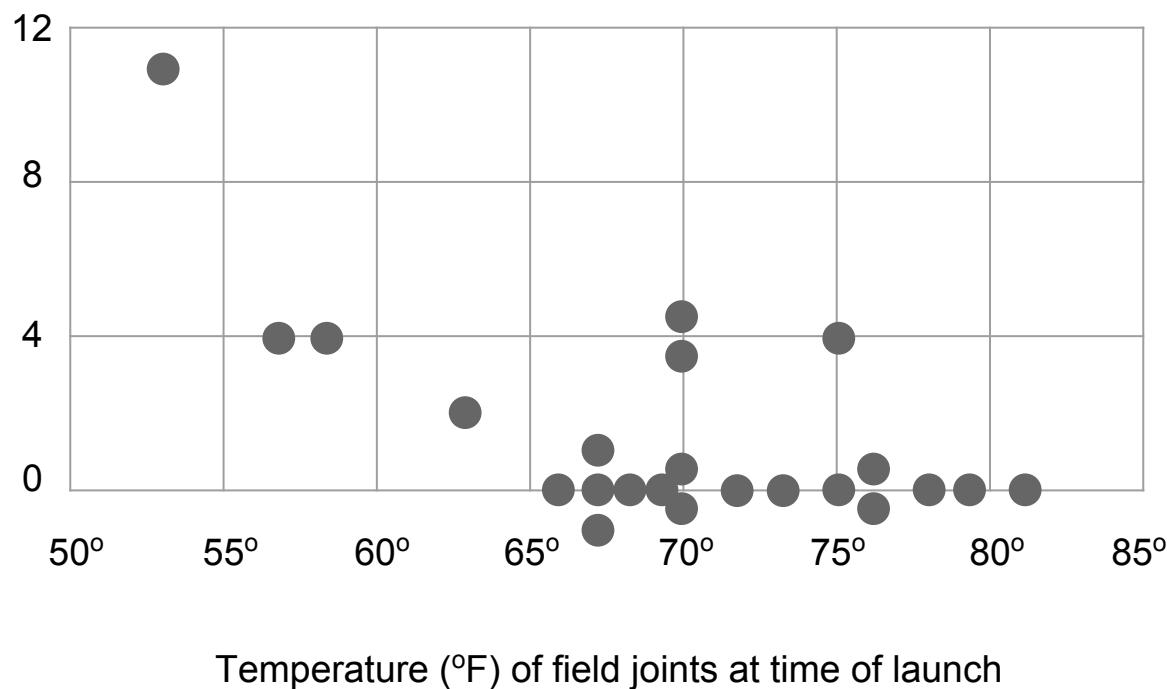




(Published in shuttle commission report; unknown date of creation)

24 launches with affected O-rings prior to the Challenger

O-ring damage
index, each launch

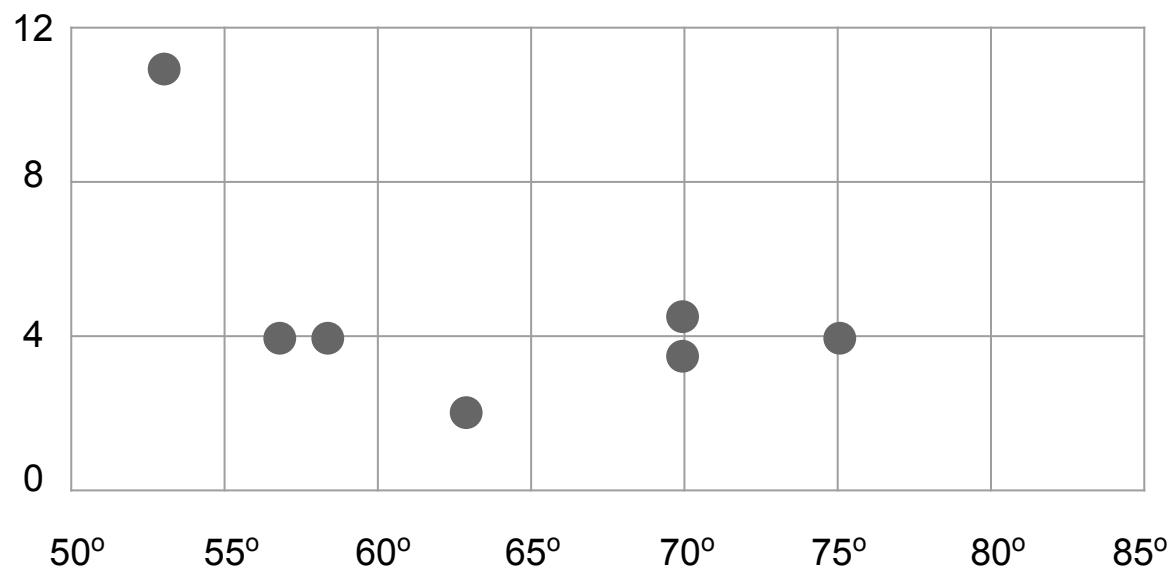


Flight	Date	Temp	Erosion Incidents	Blow-by Incidents	Damage Index	O-ring Damage
51-C	01.24.85	53	3	2	11	yes
41-B	02.03.84	57	1		4	yes
61-C	01.12.86	58	1		4	yes
41-C	04.06.84	63	1		2	yes
1	04.12.81	66			0	no
6	04.04.83	67			0	no
51-A	11.08.84	67			0	no
51-D	04.12.85	67			0	no
5	11.11.82	68			0	no
3	03.22.82	69			0	no
2	11.12.81	70	1		4	unknown
9	11.28.83	70			0	no
41-D	08.30.84	70	1		4	no
51-G	06.17.85	70			0	no
7	06.18.83	72			0	no
8	08.30.83	73			0	no
51-B	04.39.85	75			0	no
61-A	10.30.85	75		2	4	yes
51-I	08.27.85	76			0	no
61-B	11.26.85	76			0	no
41-G	10.05.84	78			0	no
51-J	10.03.85	79			0	no
	06.27.82	80			?	unknown
51-F	07.29.85	81			0	no

Values in red were exhibited at some point in the 13 pre-launch charts; those in black were not included

7 launches with affected O-rings prior to the Challenger

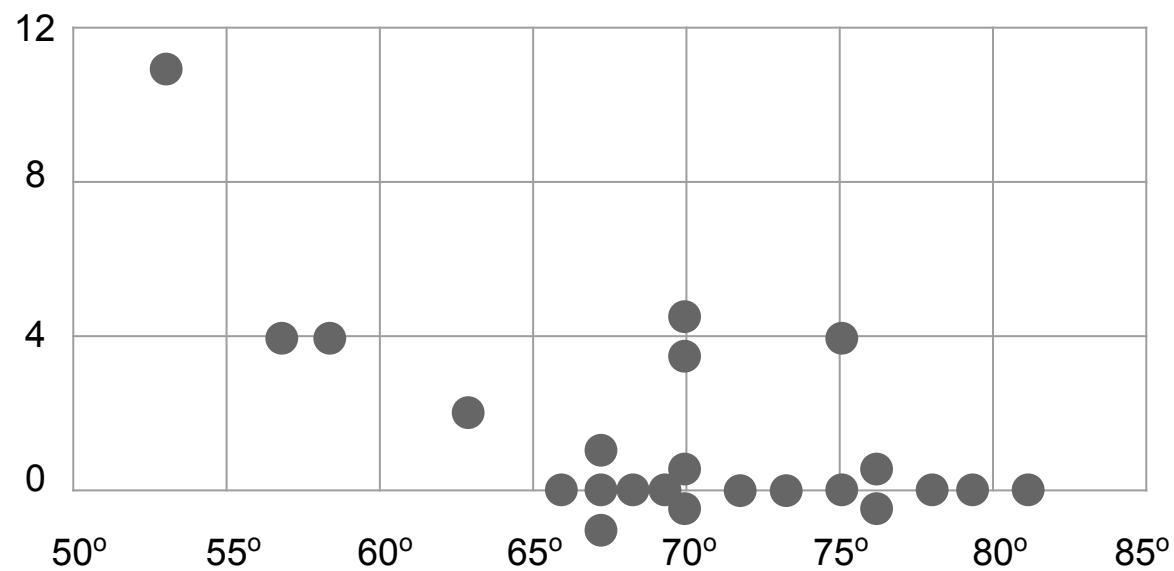
O-ring damage
index, each lunch



Temperature (°F) of field joints at time of launch

24 launches with affected and unaffected O-rings prior to the Challenger

O-ring damage
index, each lunch

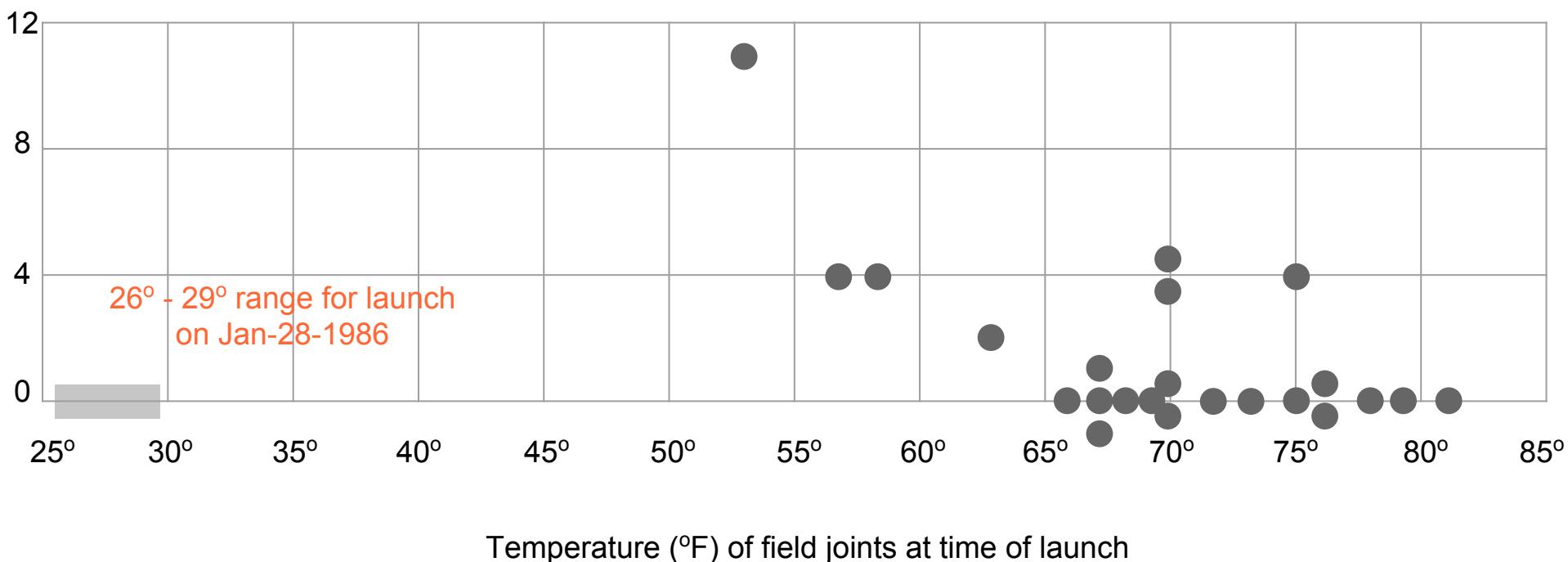


Temperature (°F) of field joints at time of launch

24 launches prior to the Challenger

O-ring damage
index, each launch

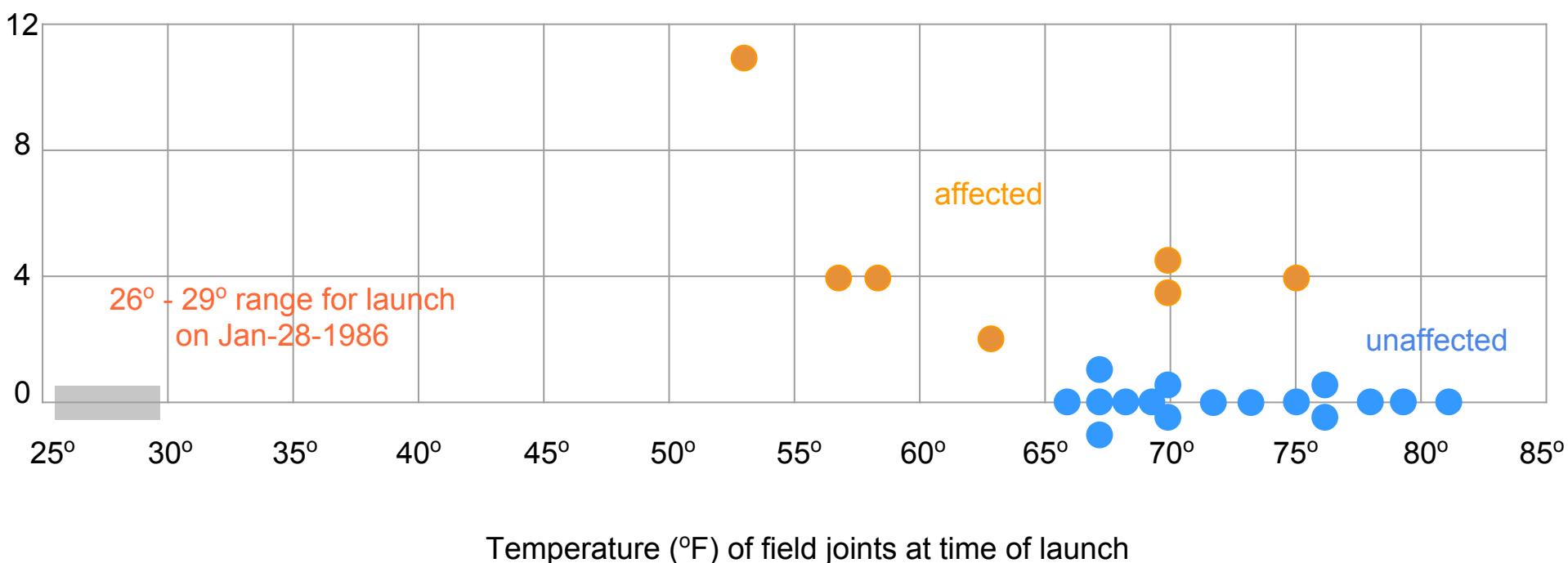
$r = -0.6415$

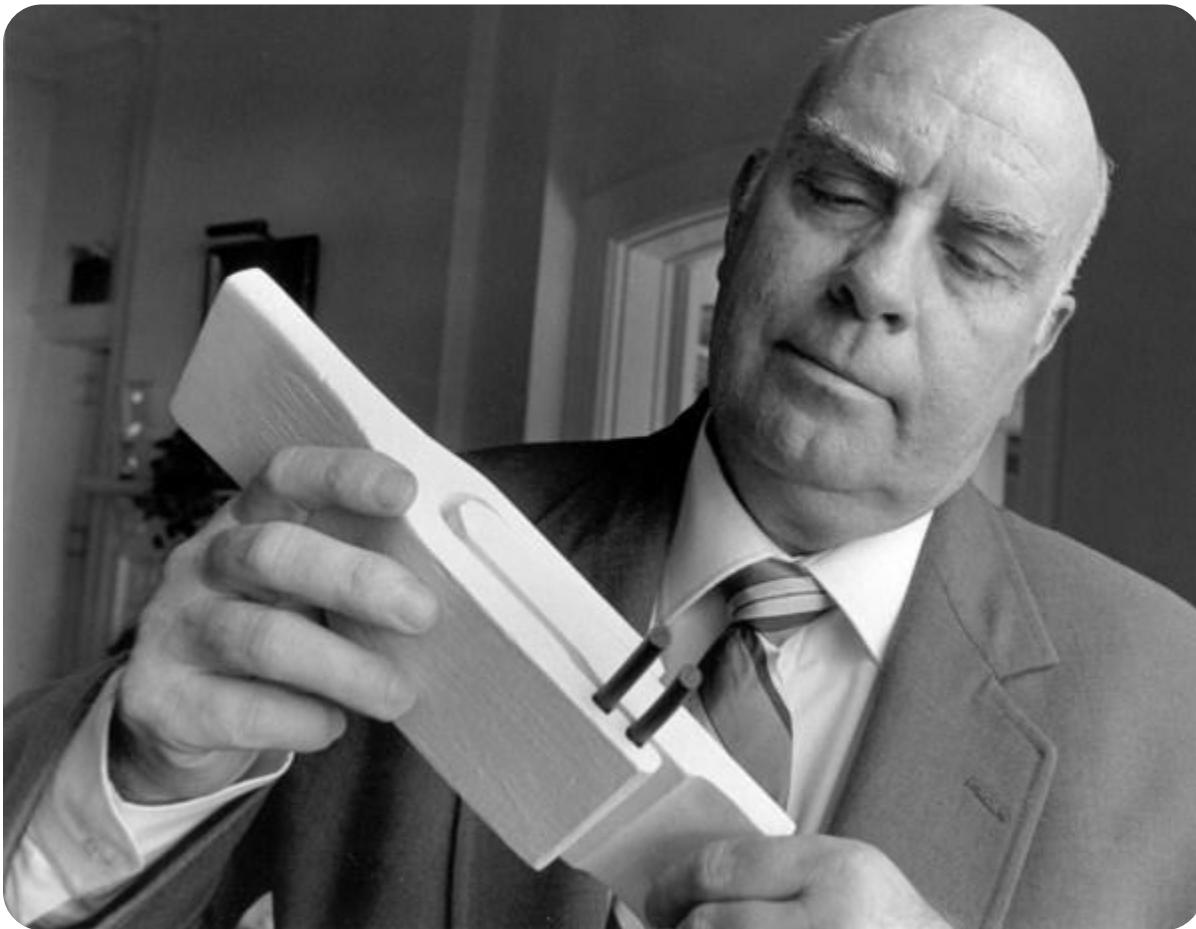


24 launches prior to the Challenger

O-ring damage
index, each launch

$r = -0.6415$





Roger Boisjoly ~ 1991
(former Morton-Thiokol engineer)



Bob Ebeling ~ 2016
(former Morton-Thiokol engineer)

Some info

- 13 charts were prepared for making the decision to launch
- 6 charts contained no tabled data about either O-ring temp, blow-by, or damage.
- The rest of charts contained no info about relation between temp and O-ring anomalies
- They all failed to reveal the risks of launching at very low temperatures

Some sources

Space Shuttle Challenger Accident

<https://www.youtube.com/watch?v=fSTrmJtHLFU>

Inside Space Shuttle Challenger STS-51L During The Accident

<https://www.youtube.com/watch?v=NnmSdVbgQ4M>

NPR article about Bob Ebeling

<http://www.npr.org/sections/thetwo-way/2016/01/28/464744781/30-years-after-disaster-challenger-engineer-still-blames-himself>