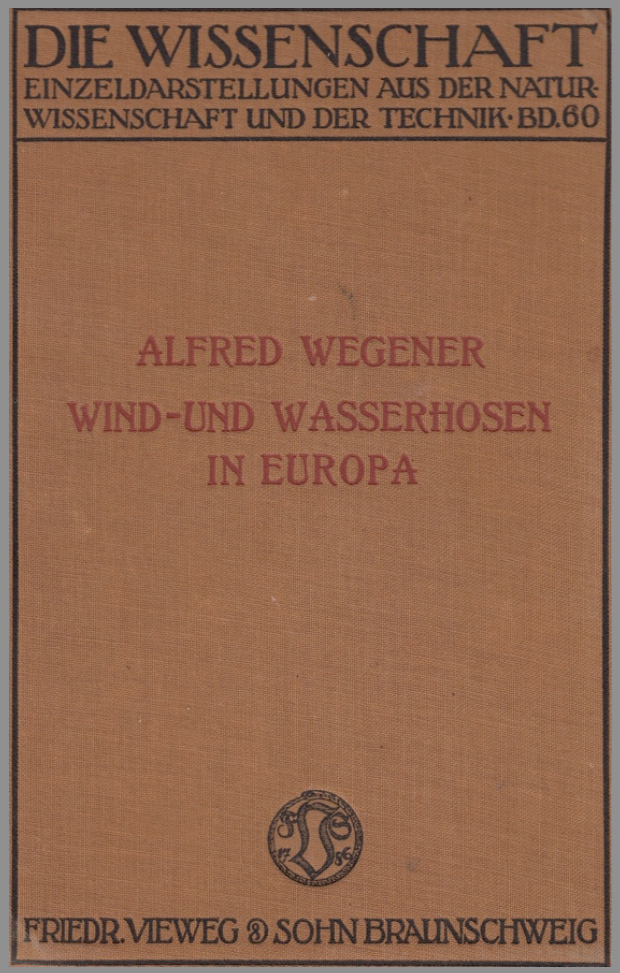
100 Years after Alfred Wegener's Opus on Tornadoes in Europe

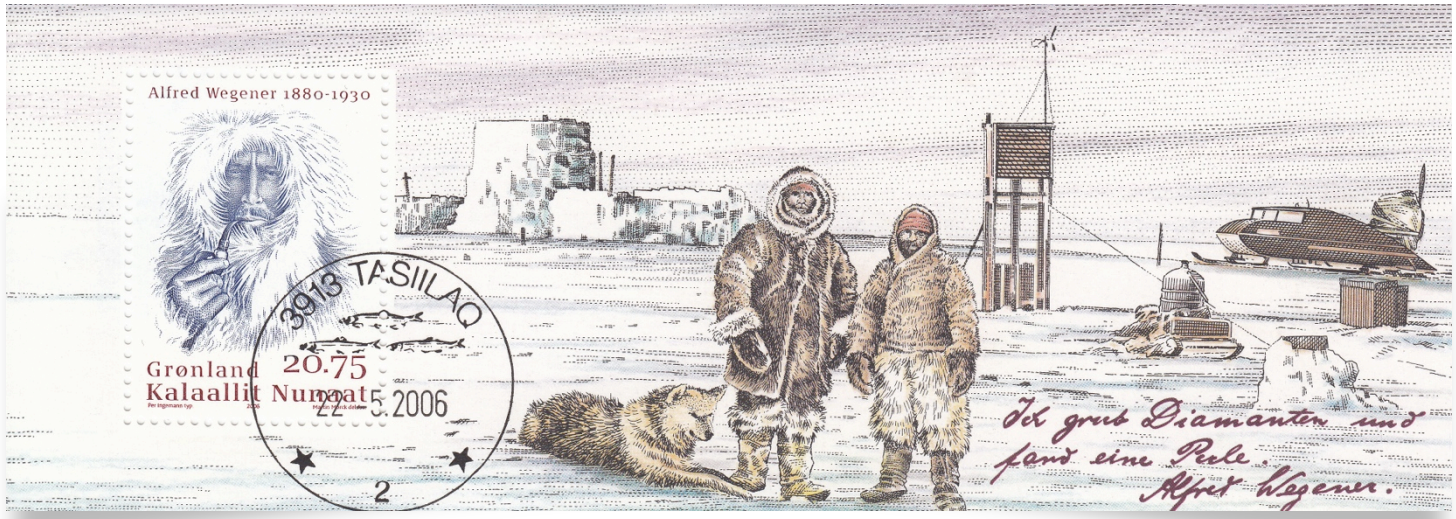
Bogdan Antonescu, David Schultz, Hugo Ricketts
University of Manchester

Wegener (1917): *Tornadoes and Waterspouts in Europe*



- catalog of tornadoes in Europe since 1456
- synthesis of proposed tornado mechanisms
- first pan-European climatology before 2014
- American versus European tornadoes

1916


Alfred Wegener 1880-1930
Grønland
Kalaallit Nunaat
20.75
3913 TASIILAQ
22.5.2006
2
Ich grub Diamanten und fand eine Perle.
Alfred Wegener.

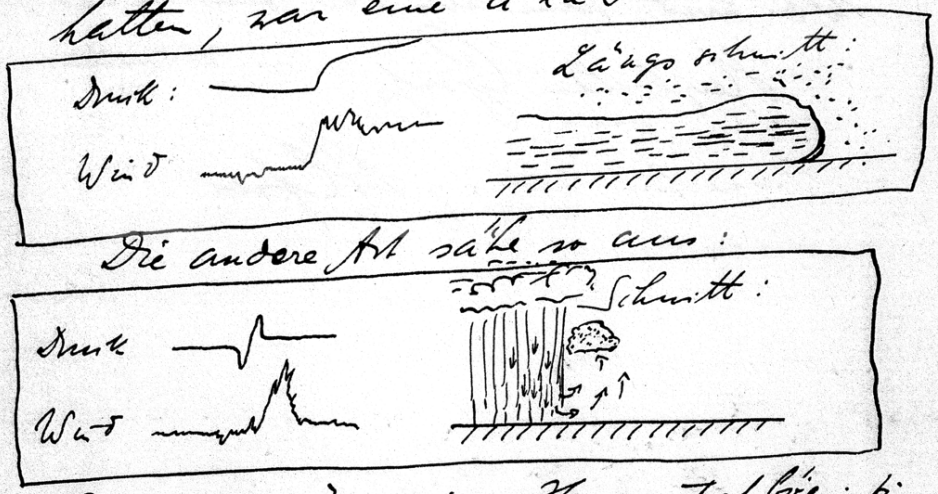

ALFRED WEGENER 1880-1930
THEORIE DER KONTINENTALVERSCHIEBUNG
60
DEUTSCHE BUNDESPOST BERLIN
1980

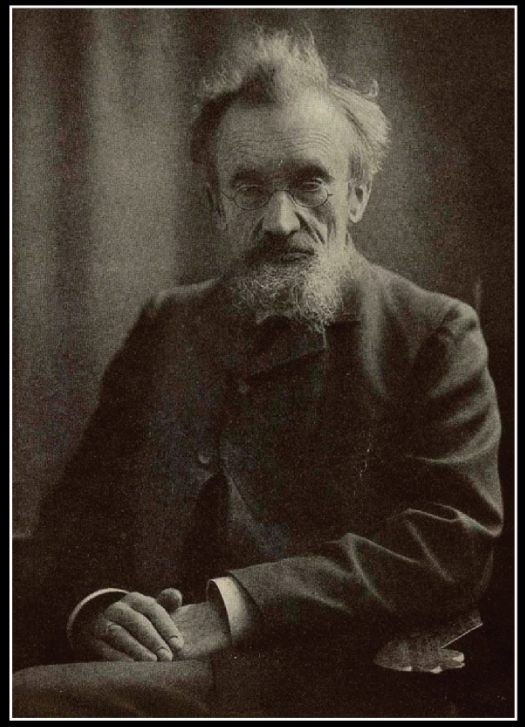

ALFRED WEGENER 1880 1930
GRÖNLAND FORSCHER
S4
REPUBLIK ÖSTERREICH
A. PILCH
1980
W. PFEILER


"The Race to the Sea"
(17 Sep–19 Oct 1914)
Puisieux (France)
(4 October)
Alfred Wegener (1914)

Mülhausen (1916)

correspondence between Alfred Wegener and Wladimir Köppen between 1915–1917 from the archive of Deutsches Museum



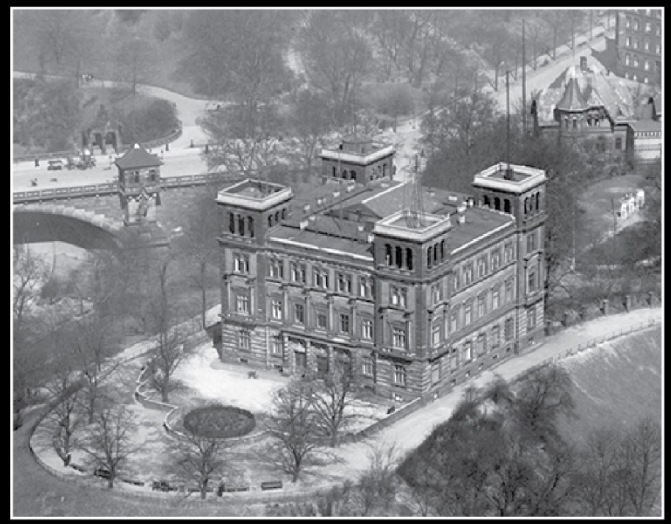


Wladimir Köppen
(1846–1940)

Julius von Hann
(1839–1921)

Gustav Hellmann
(1854–1939)

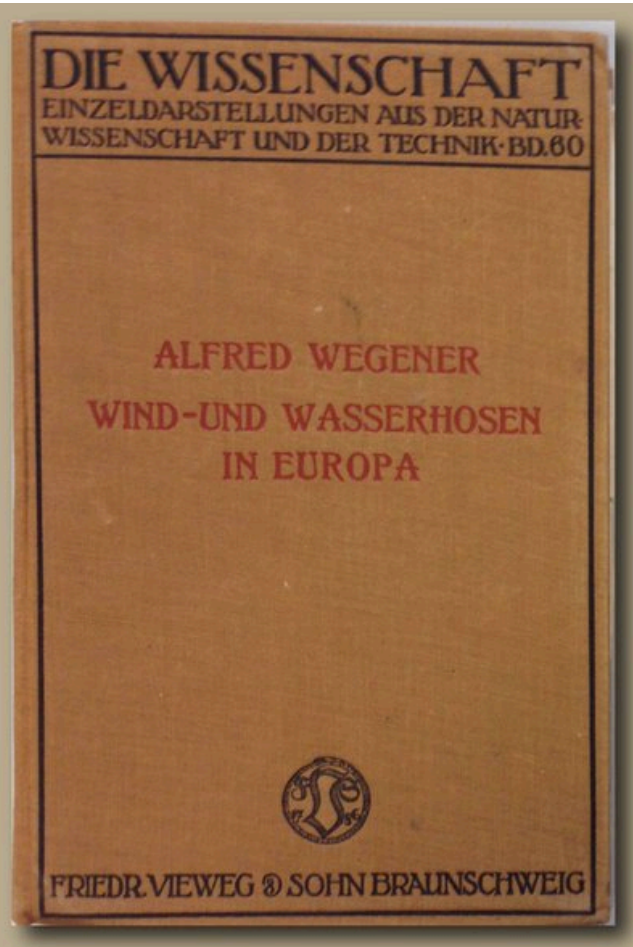
Bibliothèque Universitaire de Freiburg

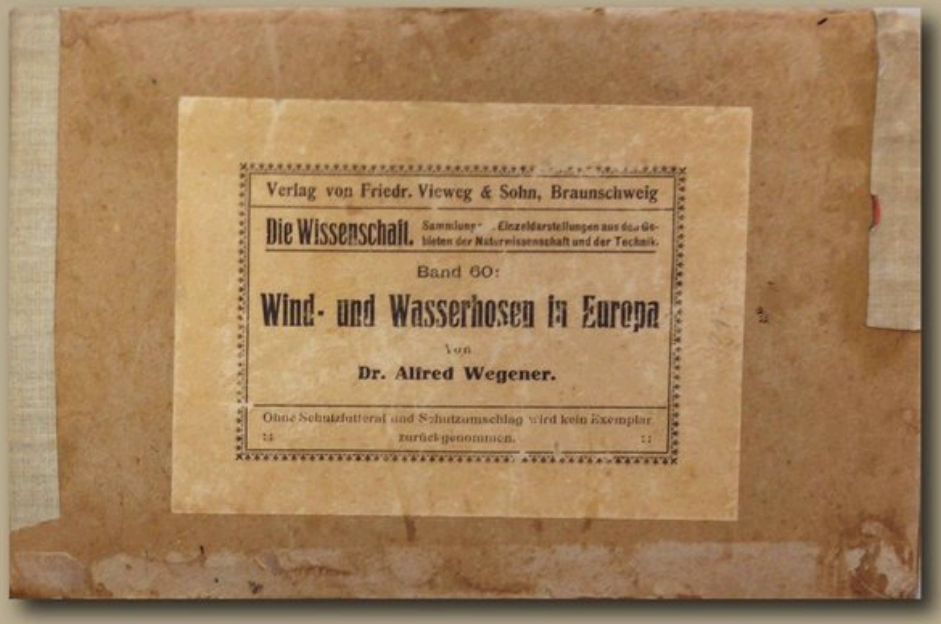


Deutsche Seewarte Hamburg

“Im Felde, im August 1916”

Alfred Wegener (1919)

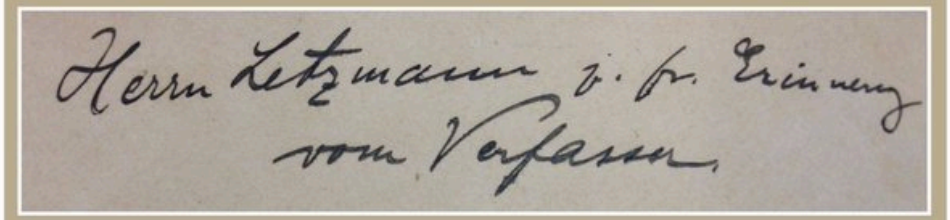


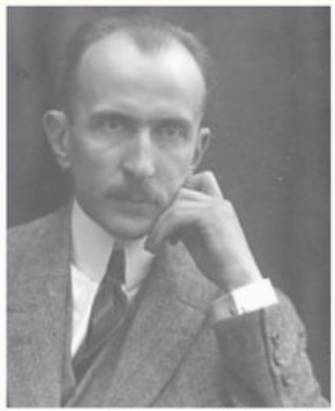


Tornadoes and Waterspouts in Europa (1917)
by Alfred Wegener
with marginalia by Johannes Letzmann

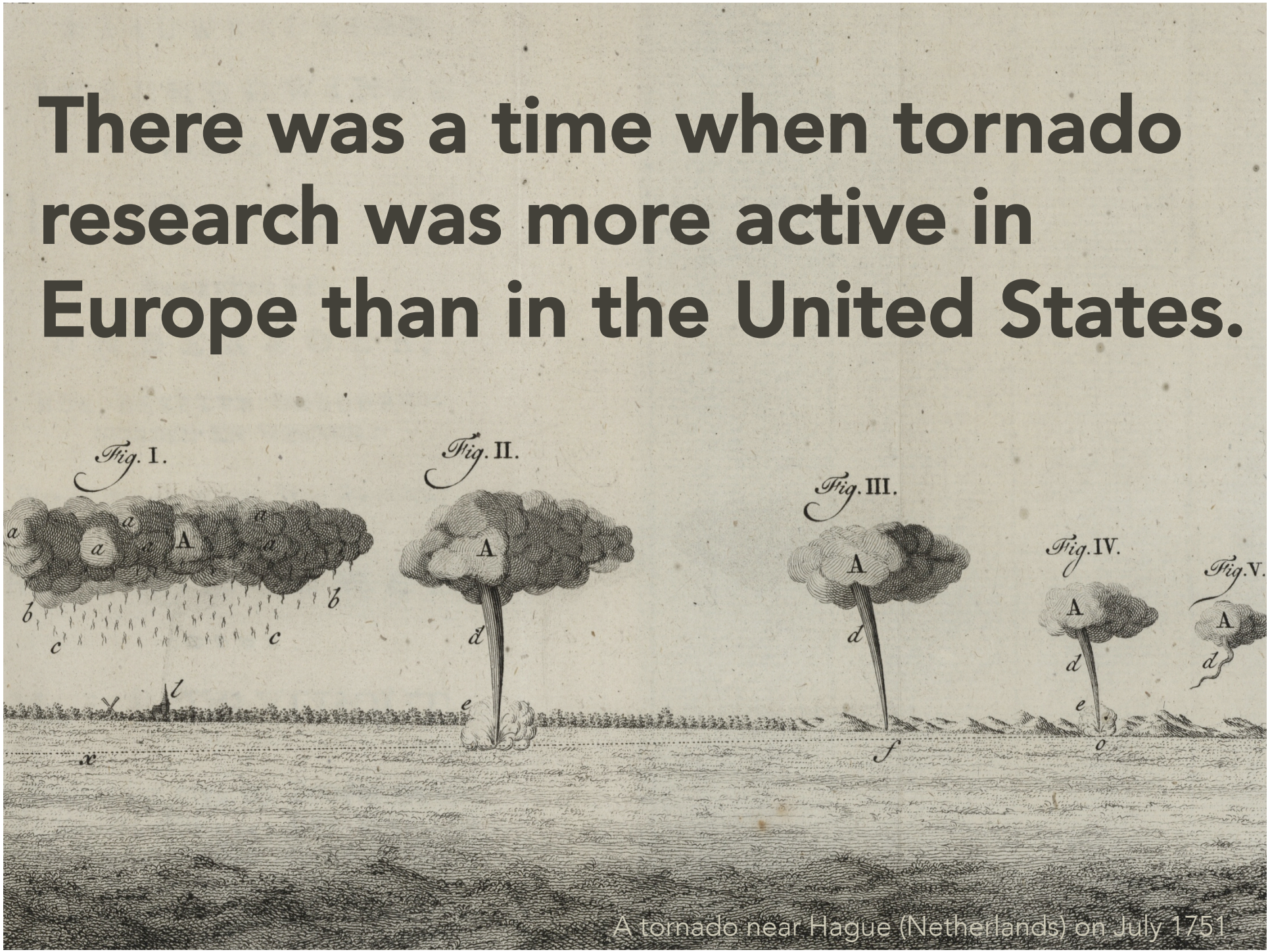

Alfred Wegener (1880–1930)

A dedication on the first page from Wegener to Letzmann




Johannes Letzmann (1885–1971)

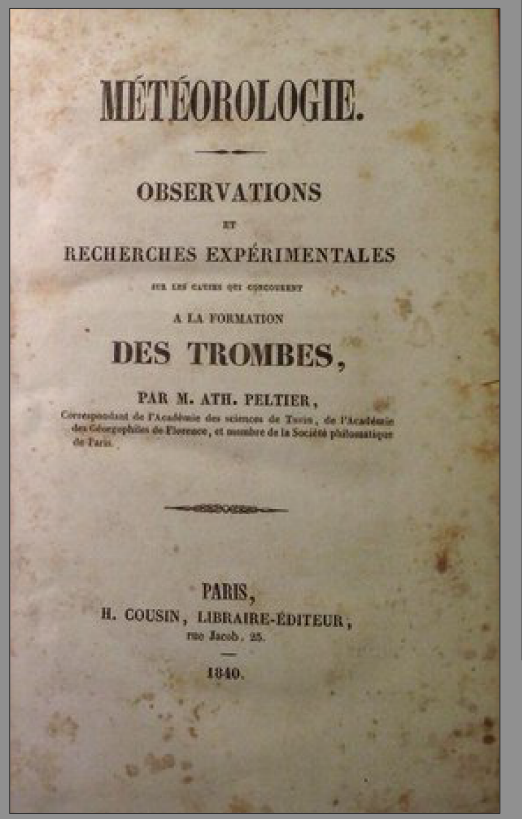
There was a time when tornado research was more active in Europe than in the United States.



A tornado near Hague (Netherlands) on July 1751

1840

Jean Charles Peltier
(1785–1845)



MÉTÉOROLOGIE.

OBSERVATIONS

ET

RECHERCHES EXPÉRIMENTALES

SUR LES CAUSES QUI CONCOURENT

A LA FORMATION

DES TROMBES,

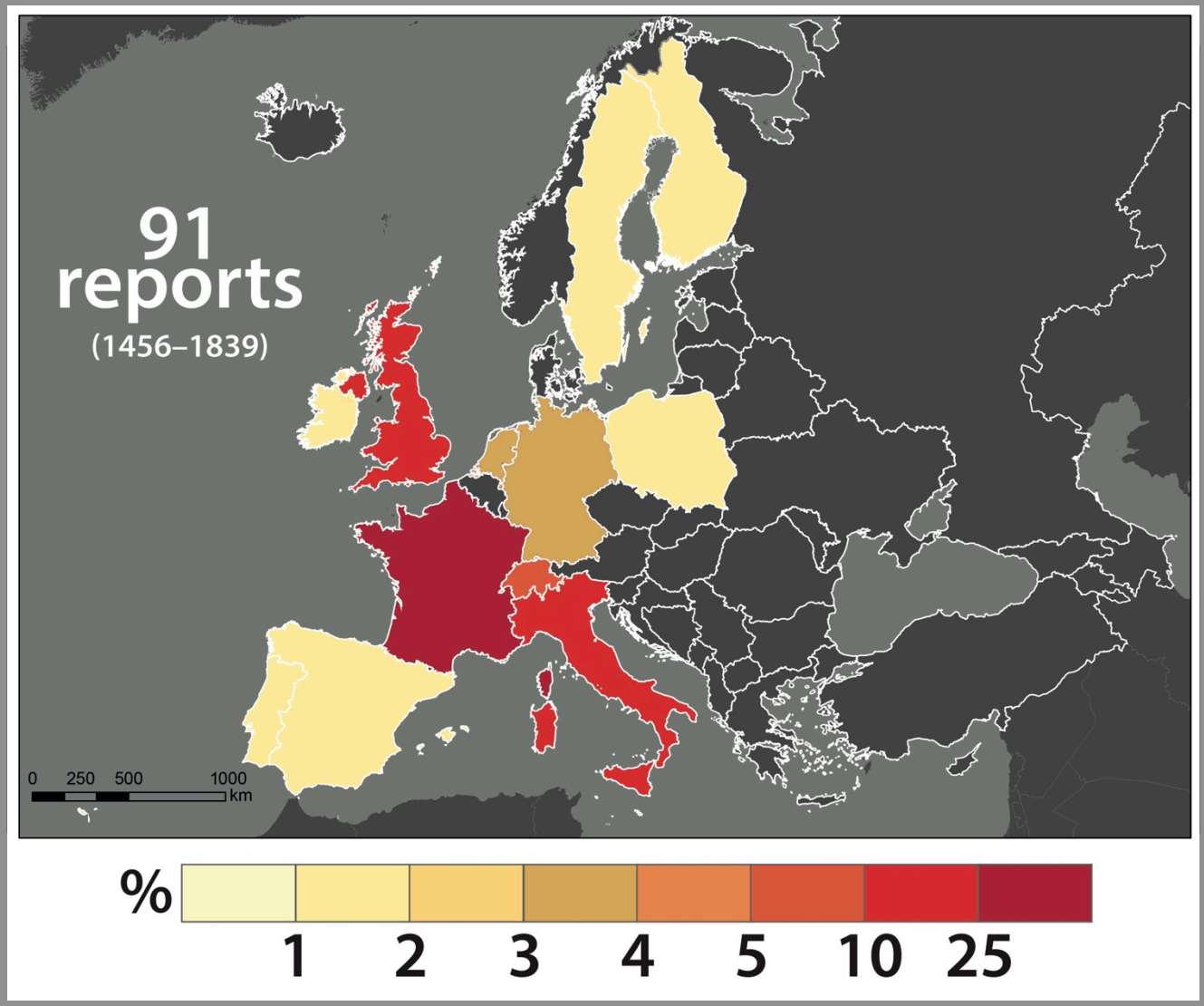
PAR M. ATH. PELTIER,

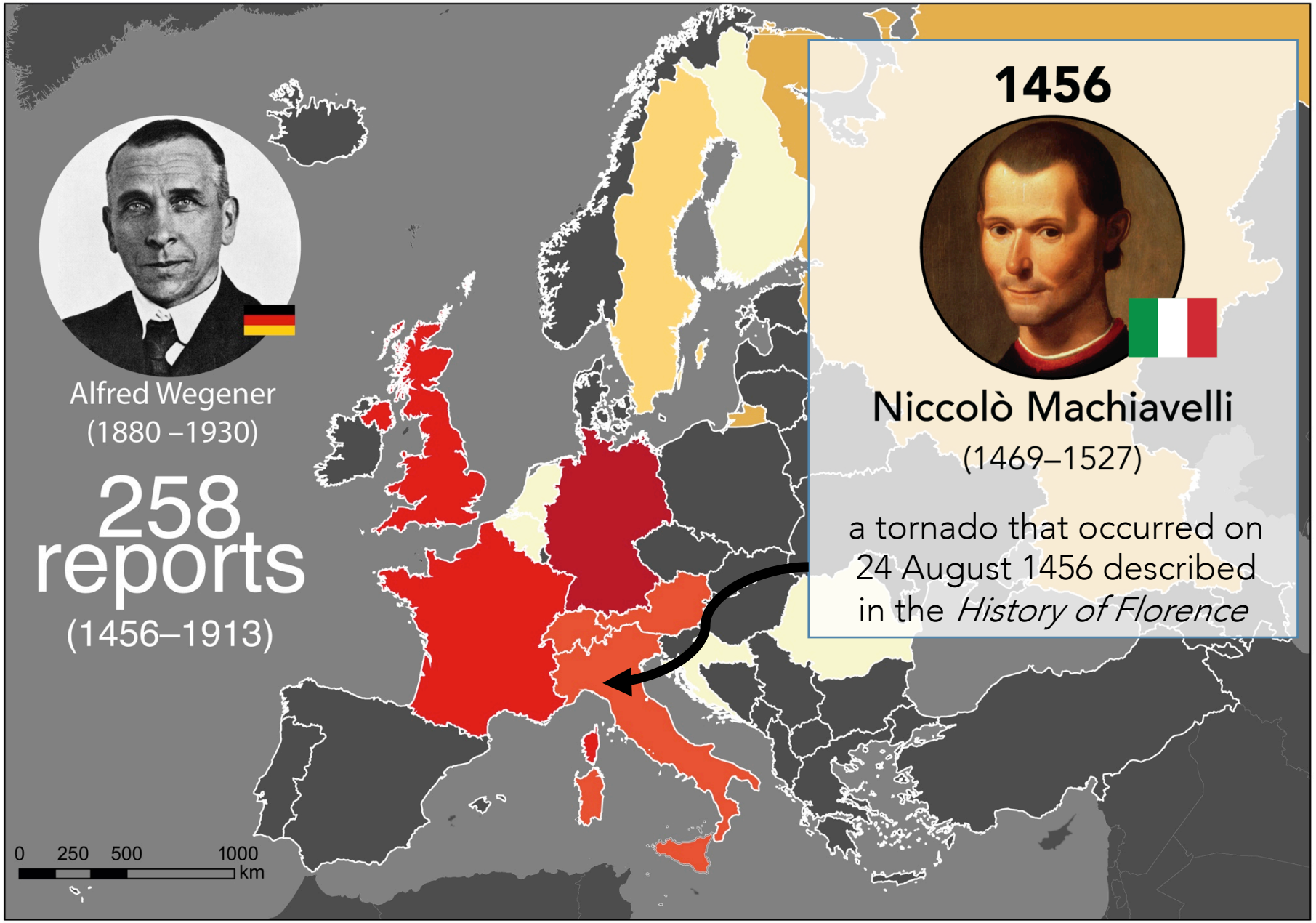
Correspondant de l'Académie des sciences de Turin, de l'Académie des Géorgophiles de Florence, et membre de la Société philomatique de Paris.

PARIS,
H. COUSIN, LIBRAIRE-ÉDITEUR,
rue Jacob, 25.

1840.

"Meteorology: Observations and experimental research on the causes that contribute to the formation of tornadoes"




1456
Niccolò Machiavelli
(1469–1527)
a tornado that occurred on 24 August 1456 described in the *History of Florence*
Alfred Wegener
(1880 –1930)
258 reports
(1456–1913)
0 250 500 1000 km
%
1 2 3 4 5 10 25

hypotheses on tornado formation

Thermodynamic hypothesis

Tornadoes are associated with atmospheric perturbations produced by sudden air dilation or contraction or by the collision of opposing winds.

1702 Alexander Stuart (1673–1742)

"Wind blows from all directions towards the whirlwind. [Whirlwinds'] motion is circular and their action attractive. [...] A common effect [of whirlwinds] is to carry up into the air, tiles, stones and animals, which happen to be in their path, and all kinds of objects unexceptionally, throwing them to a considerable distance, with great violence."

(Boscovich, *Sopra il Turbine*, 1749)

1749 Roger Joseph Boscovich (1711–1787)

1778 Johann Reinhold Forster (1729–1798)

1785 Lazzaro Spallanzani (1729–1799)

1807 Jean-Baptiste Lamarck (1744–1829)

1817 Alexander Tilloch (1759–1825)

1832 Xavier de Maistre (1763–1852)

"[Tornadoes] are the air above the thunderstorms, descending to fill the considerable vacuum [...] produced by the sudden displacement of a large quantity of electric matter. [The descending air] is constrained on all sides by the lateral pressure of the atmospheric layers, then an intense whirlwind is produced that pierces the cloud and carries with it hazy particles and forms in the same cloud an inverted cone and the moving column of smoke which is the tornado."

(Lamarck, *Annuaire Météorologique*, 1807)

1736 Thomas Shaw (1694–1751)

1769 Pieter van Musschenbroek (1692–1761)

1776 François Rozier (1734–1793)

1780 William Falconer (1732–1769)

1790 Gaspard Monge (1746–1818)

1814 William John Napier (1786–1834)

1832 Giambattista Pianciani (1784–1862)

1839 Hans Christian Ørsted (1777–1851)

"The source of these whirlwinds comes not from below. Nothing regarding the Earth's surface seems to be related to this phenomenon. Whirlwinds form on the most diverse surfaces and over waters. They are not produced by winds, since they form in a calm atmosphere. Thus, their origin is in the upper regions."

(Ørsted, *Bibliothèque Universelle*, 1839, 45)

356–330 BC Aristotle (384–322 BC)

65 AD Seneca (4 BC–65 AD)

1686 Guy Tachard (1651–1712)

"[The whirlwind] originates in the failure of an incipient hurricane to escape from its cloud: it is due to the resistance which generates the eddy, and it consists in the spiral which descends to the earth and drags with it the cloud which it cannot shake off. It moves things by its wind in the direction in which is blowing in straight line and whirls round by its circular motion and forcibly snatches up whatever it meets."

(Aristotle, *Meteorologica*, translation by M. Wilson, 2013)

1770 Jérôme Richard (1720–1770)

1835 Th. Page (?–?)

Mechanical hypothesis

Tornadoes are produced by the winds trapped in the cloud spinning around trying to get out and producing cone or column shaped clouds.

~85 BC Lucretius (90–50 BC)

77 AD Pliny the Elder (23 AD–79 AD)

1663 Jean-Baptiste du Hamel (1624–1706)

1696 Nicolaas Hartsoeker (1656–1725)

"A pillar, so to speak, is let right down
From sky to sea, round which the surges boil
Lashed by the blowing winds, and ships that are
Caught in that turmoil come in greatest risk.
And this takes place sometimes when the wind's force
Can't burst the cloud it aimed at, but can urge
It downwards, like a pillar that is set
'Tween sea and sky, coming by slow degrees,
Pushed and extended as t were from above
Over the waves by strength of arm and hand:
And when the cloud is rent, the force of wind
Bursts forth upon the sea, and raises up
A wondrous surging in the waves around:
The eddy whirling round descends and brings
Yon cloud of pliant body down with it:
And having thrust it, heavy as it is,
Down to the level of the sea, the eddy then
Plunges itself entire into the waves,
And stirs the ocean with terrific noise,
And makes it boil [...]."

(Lucretius, *De Rerum Natura*
translation from Latin by Sir Robert Allison, 1919)

Electrical hypothesis

Tornadoes are a result of cloud electrification which can produce intense wind by accelerating charged cloud particles in an electric field.

1753 Giovanni Battista Beccaria (1716–1781)

1776 Mathurin Jacques Brisson (1723–1806)

1807 Thomas Young (1773–1829)

1823 Johann Caspar Horner (1774–1834)

1832 Frederick William Beechey (1796–1856)

"Electricity is the cause of whirlwinds as shown by an experiment in which an electric conductor is used to suspend a water droplet above a jar filled with water. When the conductor is charged the suspended water droplet is elongated and the surface of the water in the jar rises forming a 'conical button'."

(Beccaria, *Traité d'Electricité artificielle et naturalle*, 1753)

1758 Johan Carl Wilcke (1732–1796)

1781 Bernard Germain de Lacépède (1756–1825)

1805 Jérôme de Lalande (1732–1807)

1828 Alexander von Humbold (1769–1859)

1837 Urbain Dortet de Tessan (1806–1879)

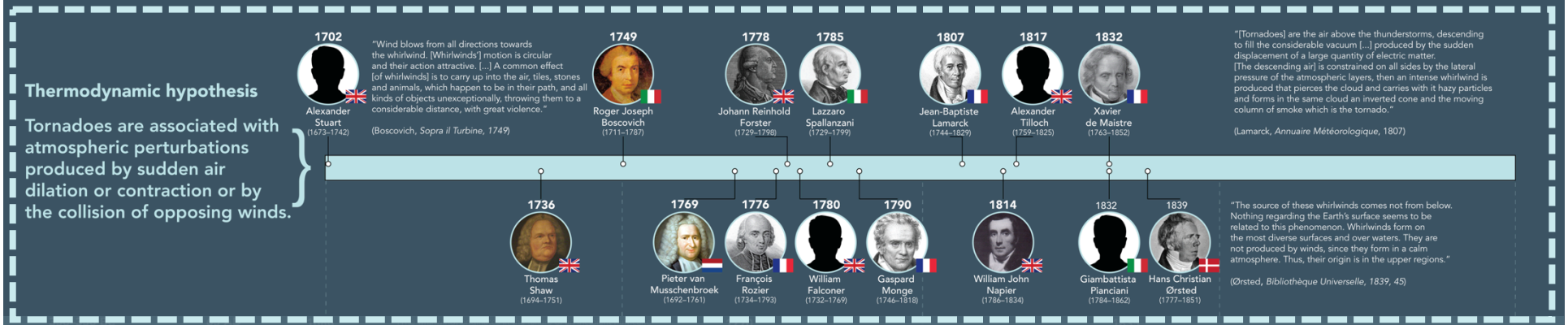
1841 Jean Charles Peltier (1785–1845)

"Everything proves the tornado to be nothing else than a conductor formed of the clouds, which serves as a passage for a continual discharge of electricity."

(Peltier, *Météorologie: Observations et recherches expérimentales sur les causes qui concourent à la formation des trombes*, 1841)

335 BC 77 AD 1700 1750 1800 1850 1900

hypotheses on tornado formation



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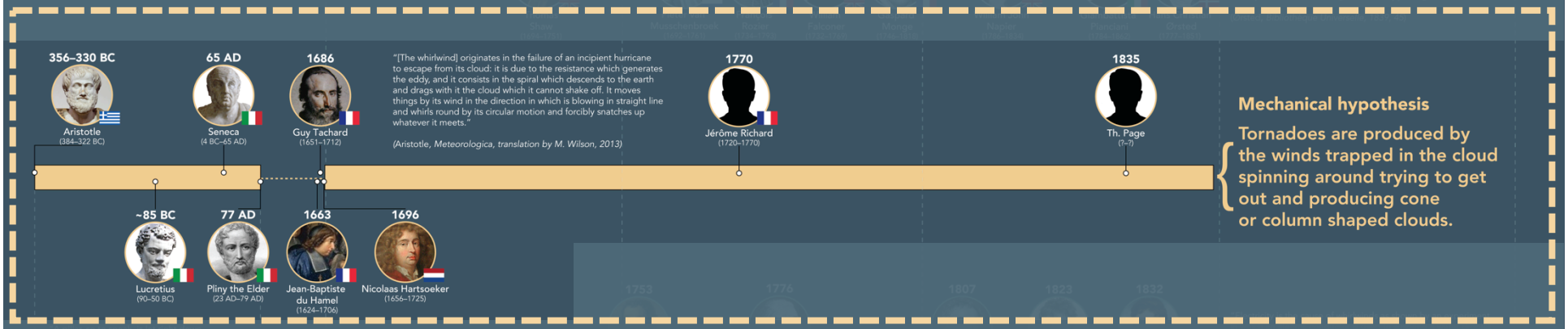

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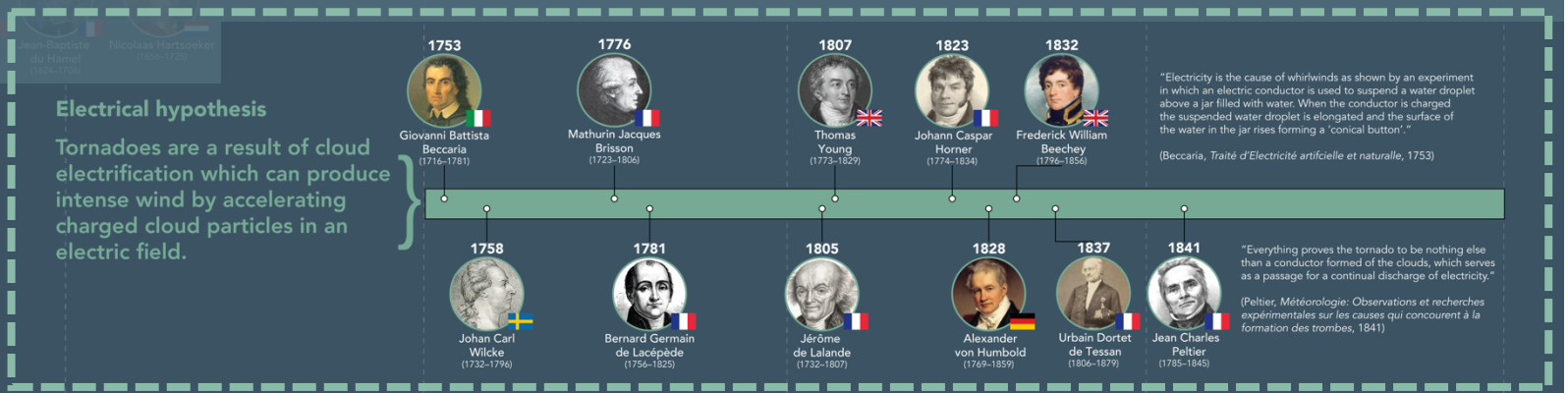
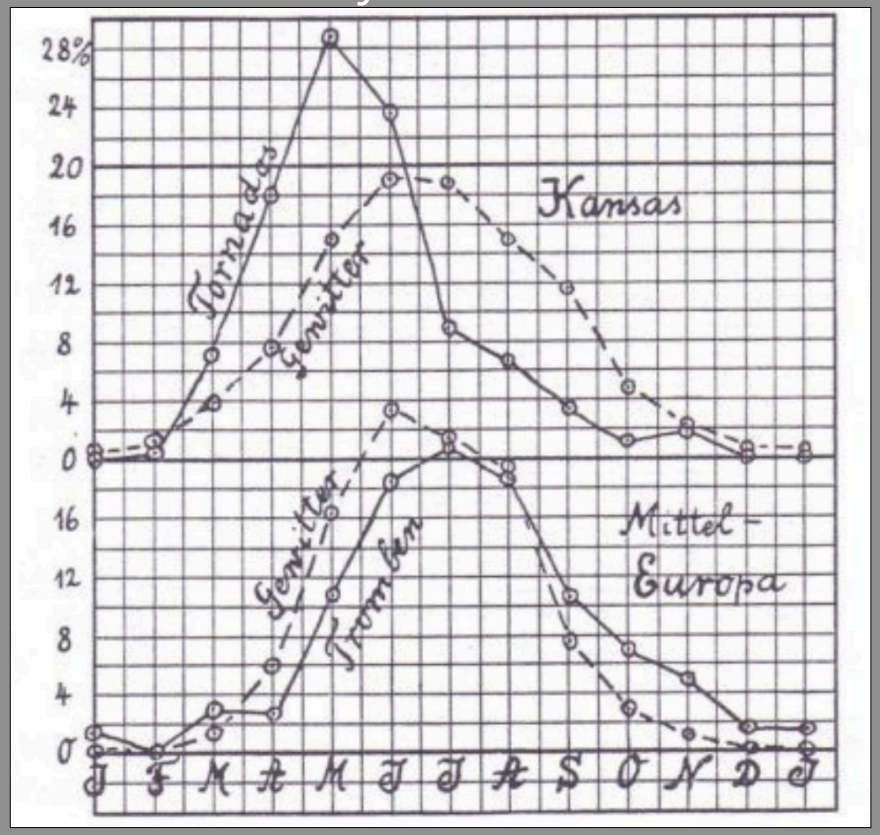
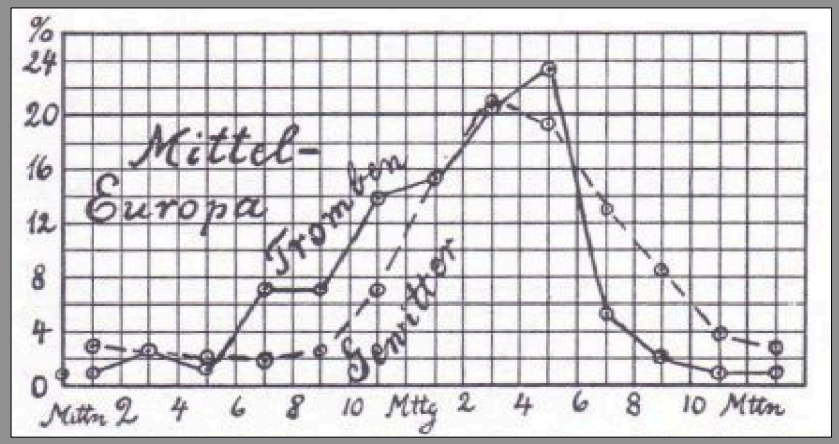


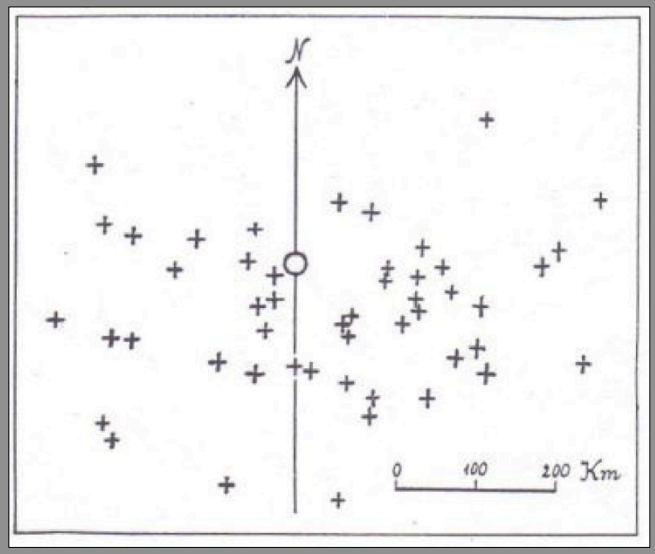
Tornadoes and Waterspout in Europe (1917)

monthly distribution



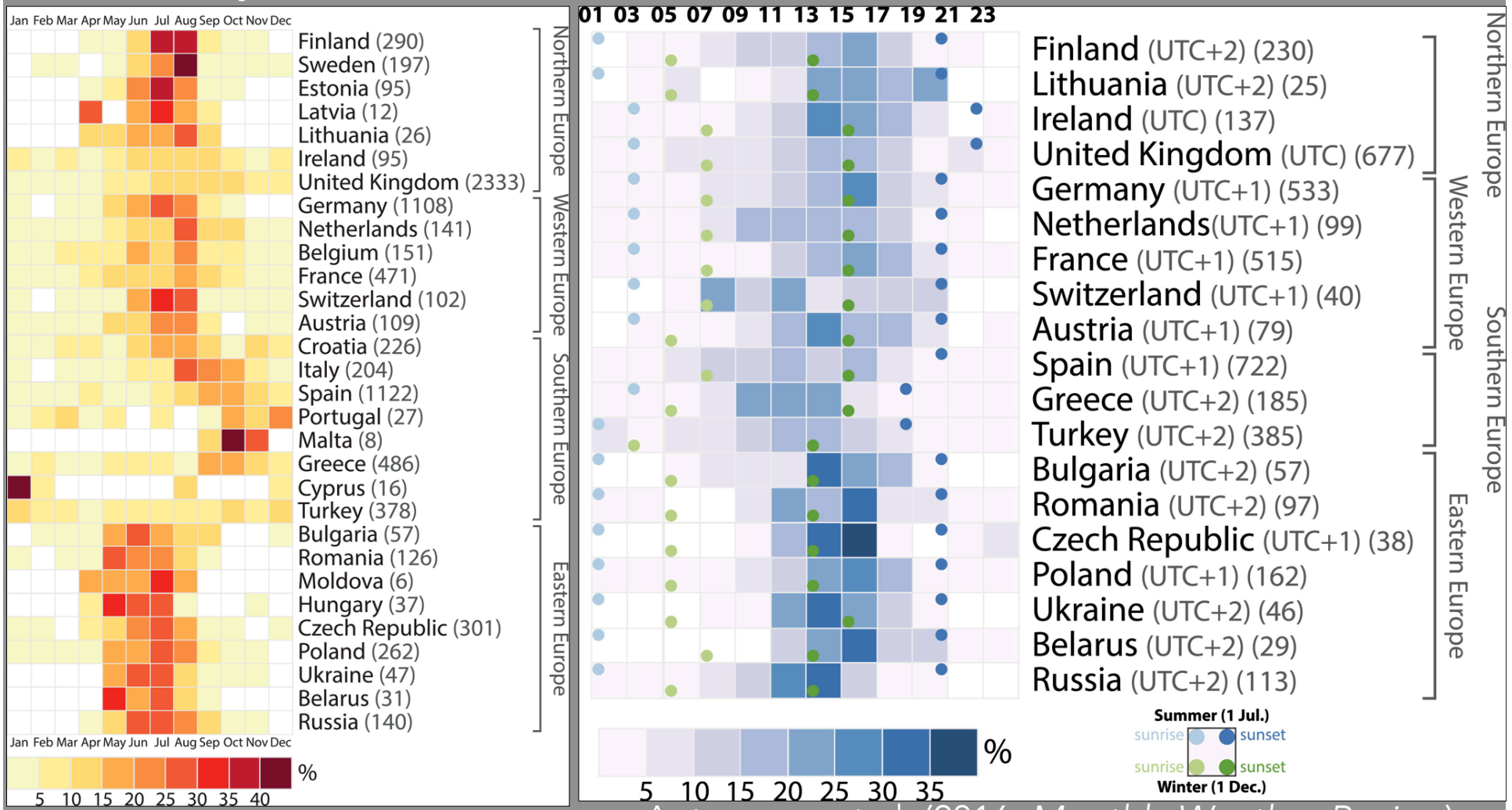
diurnal distribution





tornado reports relative
to the centre of the low
pressure system

Tornadoes in Europe: Synthesis of the Observational Datasets (2016)

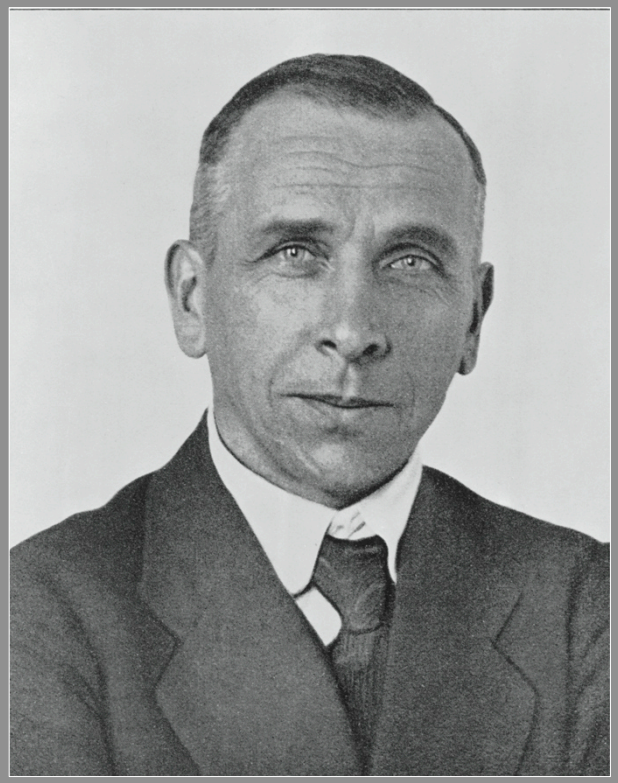


Antonescu et al. (2016, *Monthly Weather Review*)

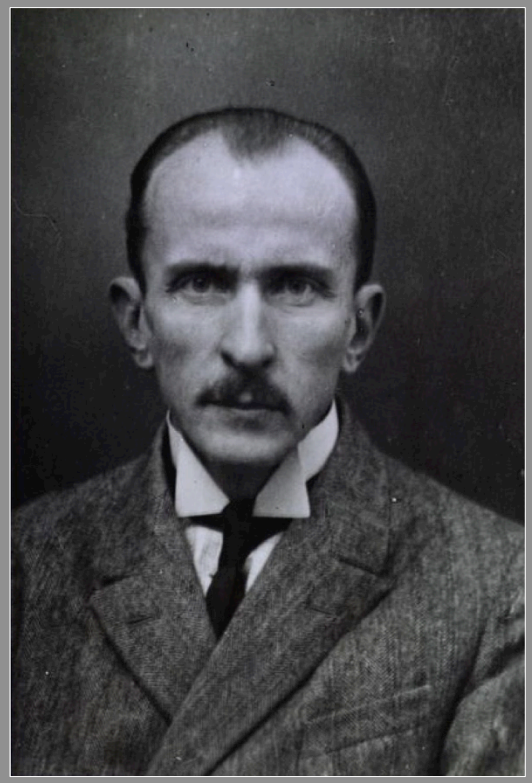
Tornado research in Europe after World War I

Contributions to the mechanics of waterspouts and tornadoes (1928)

Guidelines for Research on Funnels, Tornadoes, Waterspouts, and Whirlwinds (1937)



Alfred Wegener
(1880–1930)



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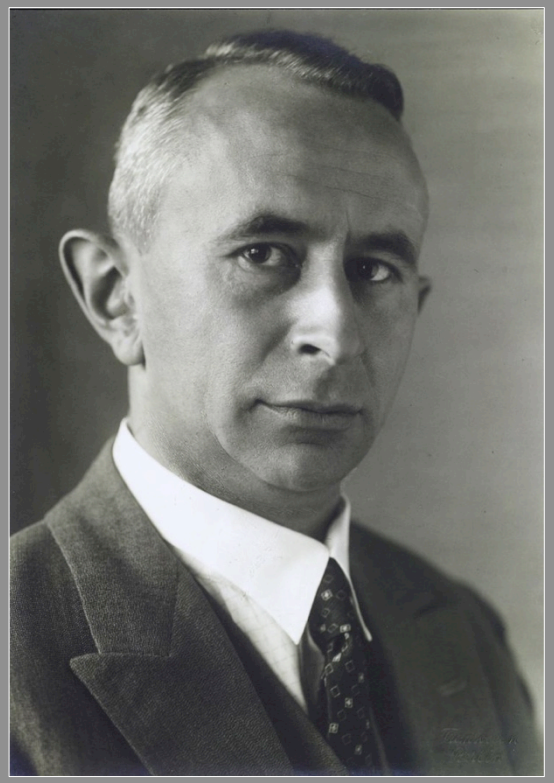
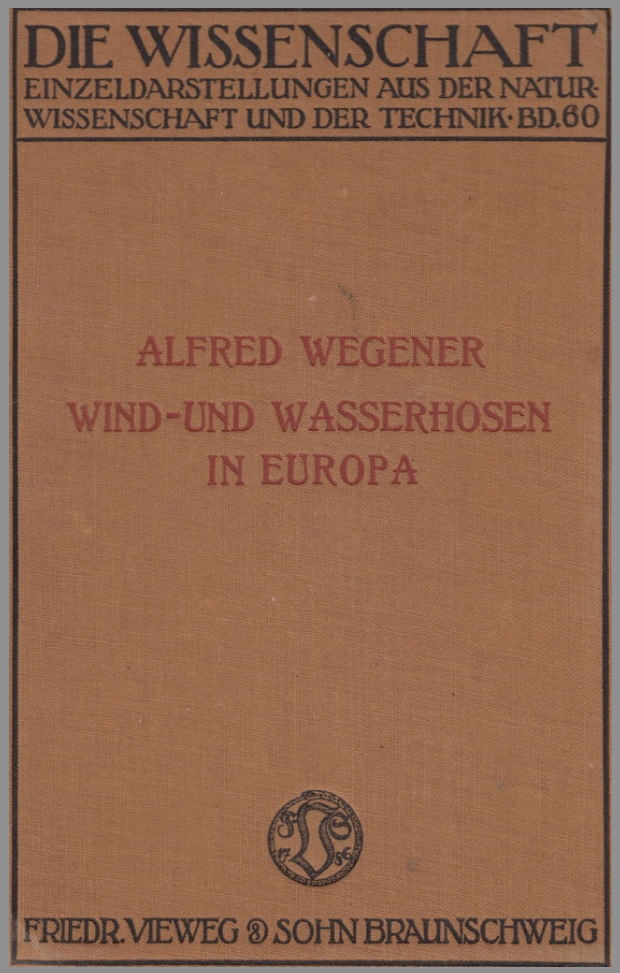


Harald Koschmieder
(1897–1966)

Wegener (1917): *Tornadoes and Waterspouts in Europe*



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