Understanding weather and the weather forecast

Week 23

Tornadoes and Lightning

Terry Hart

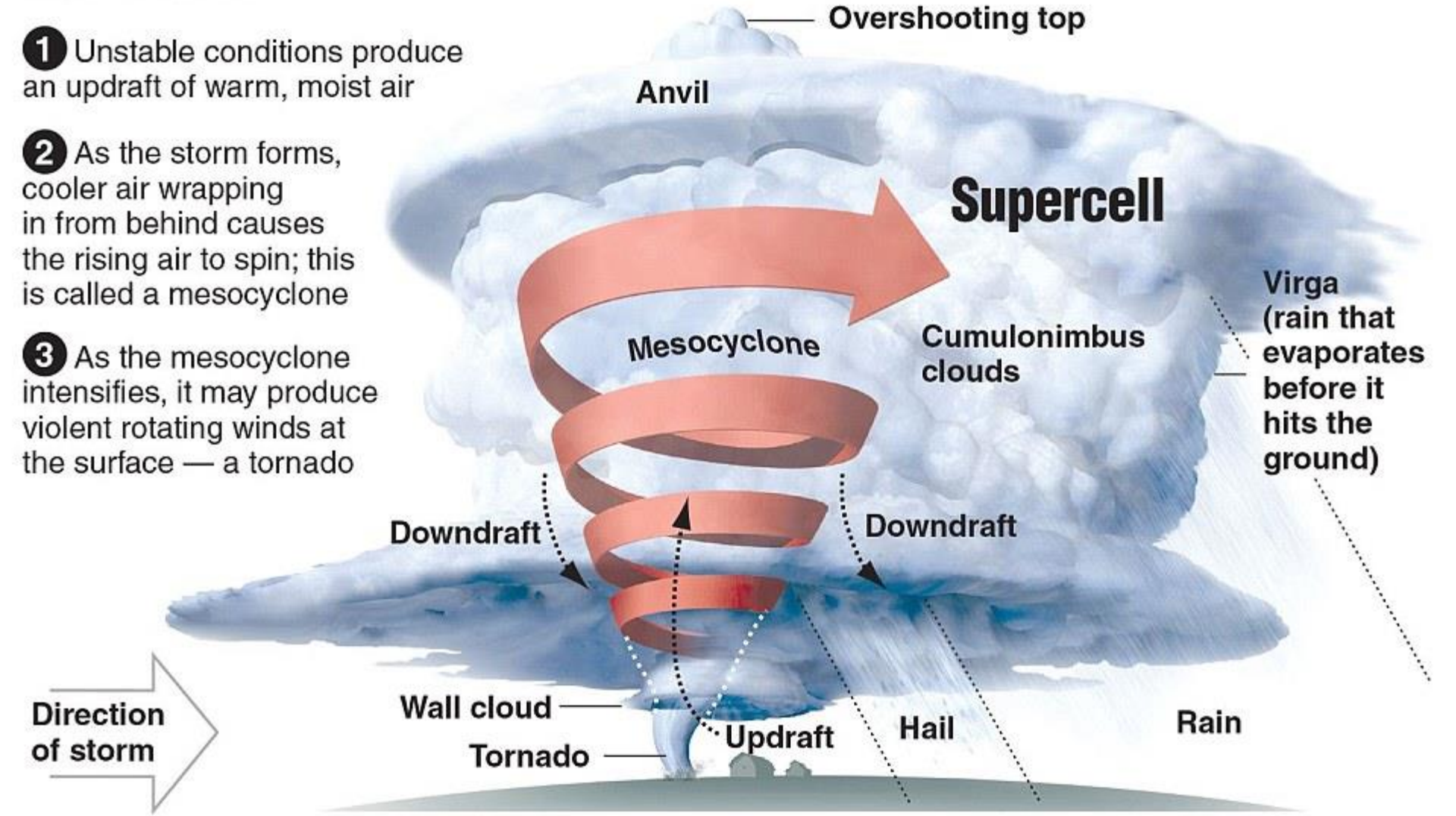
Tornadoes

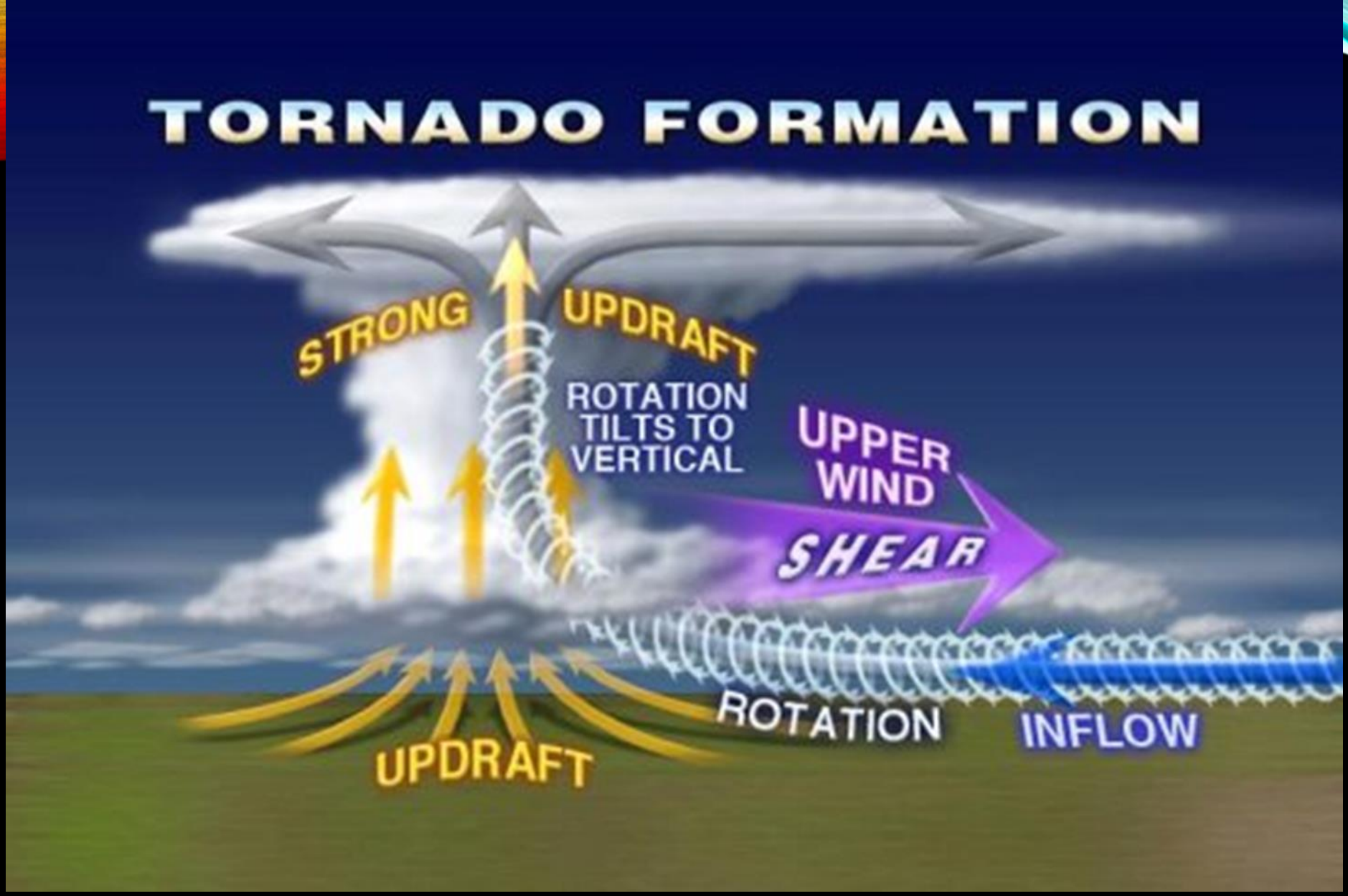
Oklahoma, 1999

Nimmitabel (NSW) 2008

Destructive vortex

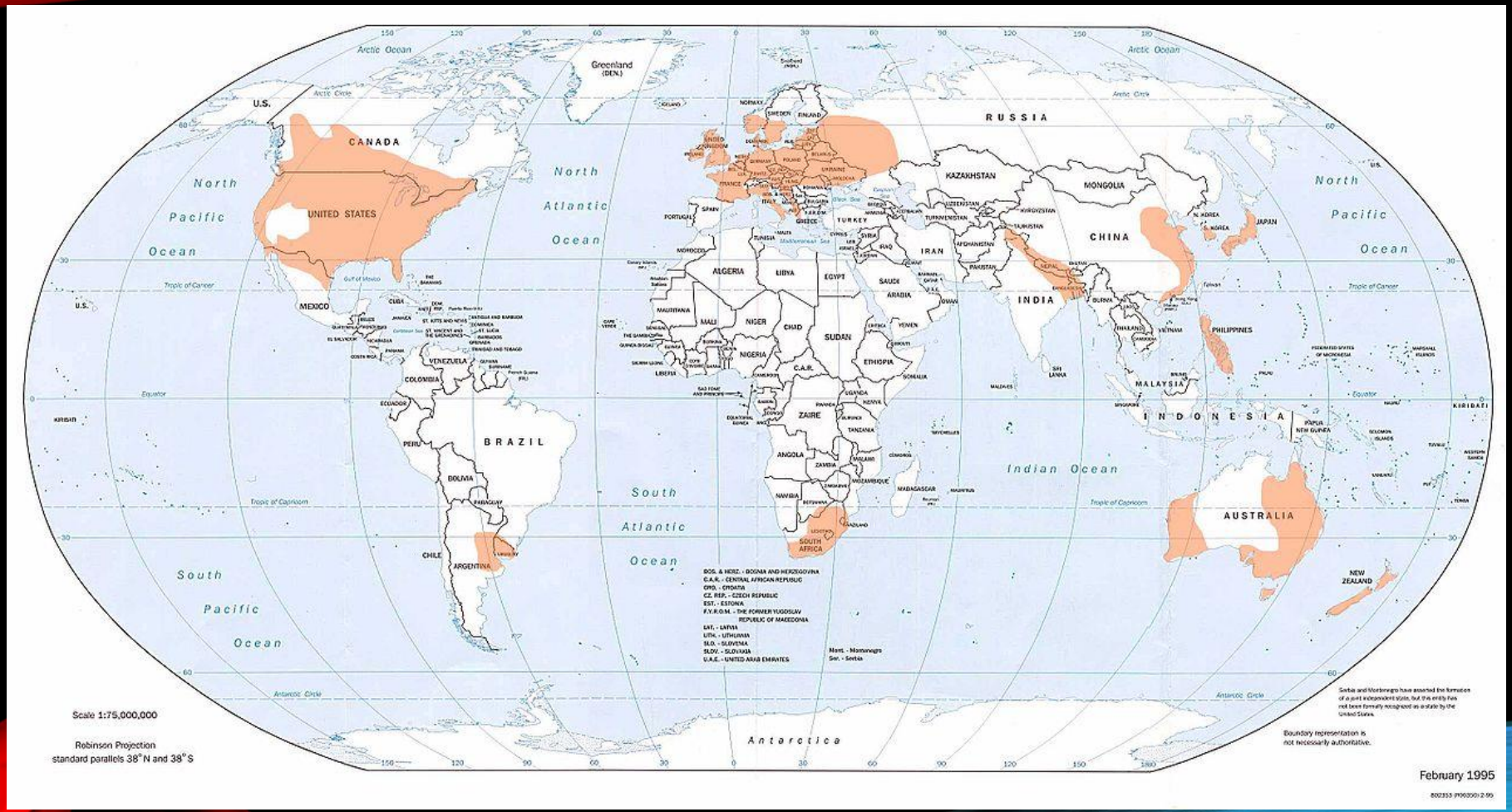
Tornadoes develop out of thunderstorms, where there's a steady, upward flow of warm, low-pressure air. Some tornadoes consist of a single vortex, but other times multiple suction vortices revolve around a tornado's center.



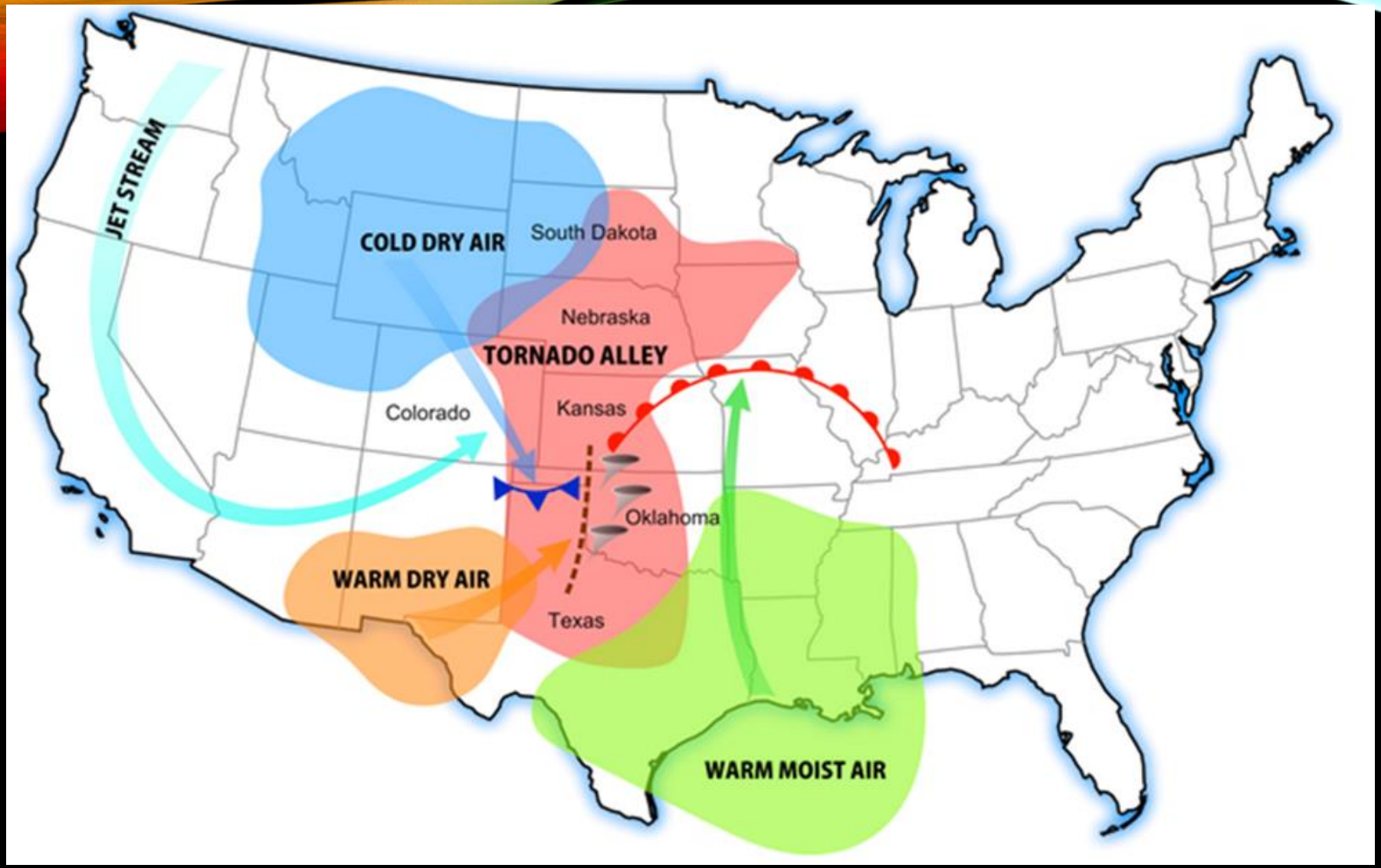


GOES-R site: https://youtu.be/LT7yRMLAkCY

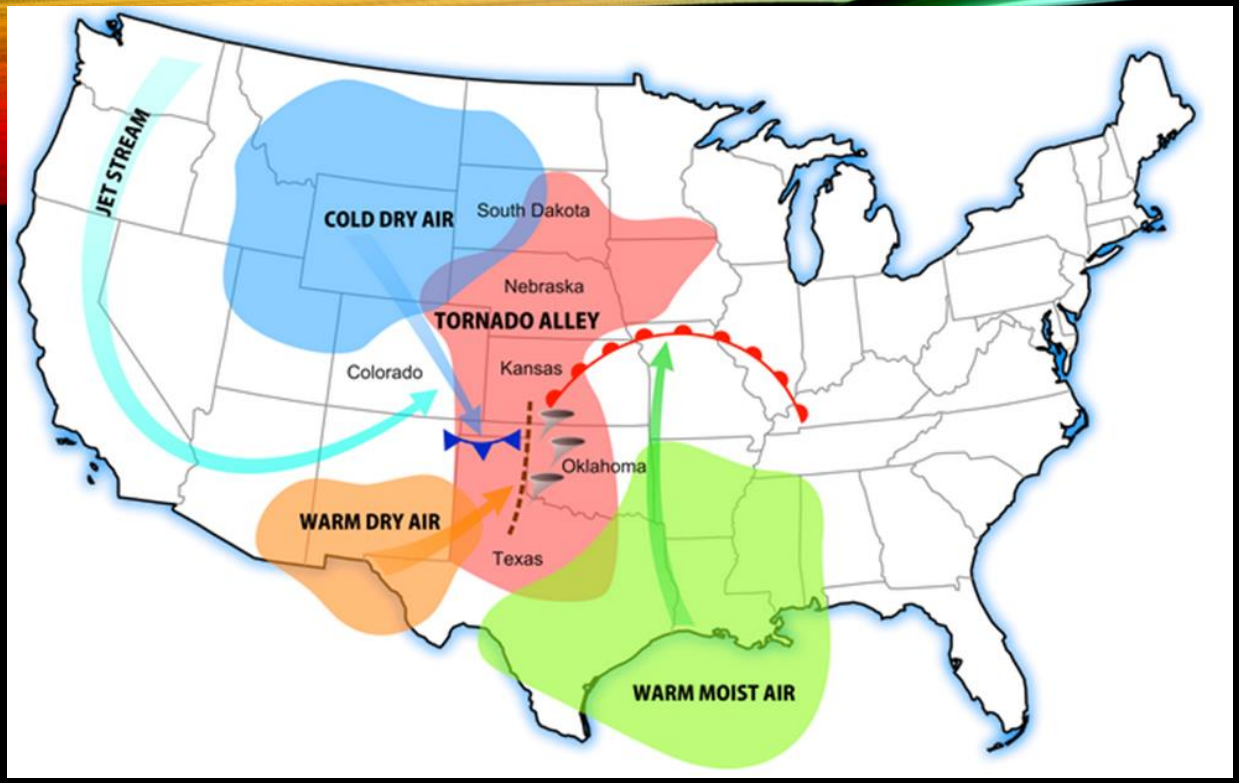
Where tornadoes occur



NOAA (USA)



https://youtu.be/lsEA9tGMFQQ Tornado Alley



The Rocky Mountains block moisture and the atmospheric flow, leading to the formation of a low pressure area downwind to the east of the mountains. The downslope winds bring drier air at mid-levels of the troposphere. On the other hand, the Gulf of Mexico fuels abundant low-level moisture in the southerly flow to its east. This unique topography allows for frequent collisions of warm and cold air, the conditions that breed strong, long-lived storms.

Fujita Scale

For assessing tornado strength from damage (developed in USA)

EF3	136–165	218–266	2.18%	Severe damage. Roofs and numerous outside walls blown away from frame homes, all trees in its path uprooted or lofted. Two-story homes have their second floor destroyed, high-rises have many windows blown out, radio towers blown down, metal buildings (i.e. factories, power plants, and construction sites) are heavily damaged, sometimes completely destroyed. Large vehicles such as tractors, buses, and forklifts are blown from their original positions.	

https://en.wikipedia.org/wiki/Enhanced_Fujita_scale

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

A damage assessment of the 20 May 2020 tornado in Waurn Ponds, VIC

Dean Sgarbossa, Joshua Soderholm, Kevin Parkyn, Peter Otto, Steven McGibbony
Bureau of Meteorology
Email: dean.sgarbossa@bom.gov.au

Note from the Editorial team: The Enhanced Fujita scale is a linear function of the Fujita scale in the previous article.

During the early morning hours of 20 May 2020, a Quasi Linear Convective System (QLCS) associated with a vigorous cold front produced a confirmed tornado that resulted in a narrow path of destruction through the southwestern suburbs of the regional city of Geelong, Victoria. A damage assessment was conducted by the Bureau of Meteorology 13 hours after the tornado event which suggested that the observed damage was consistent with an Enhanced Fujita Scale tornado intensity rating of EF1 with maximum 3-second wind gust speeds of 138–178 km/h.

wind gusts and a number of possible tornadoes. Thunderstorms embedded within the QLCS intensified rapidly as they approached the Geelong area with at least one thunderstorm displaying radar evidence of deep vertical rotation associated with a supercell thunderstorm (Figure 1). This particular thunderstorm subsequently produced a confirmed tornado that left a narrow path of destruction through the suburbs of Waurn Ponds, Grovedale and Mount Duneed located southwest of the regional city of Geelong, Victoria between 01:10 and 01:13 Australian Eastern Standard Time (AEST), resulting in 212

"the damage assessment suggested an EF-scale intensity rating of EF1 with maximum 3-second wind gust speeds of 138–178 km/h."

- Most tornadoes have wind speeds less than 180 km/h, are about 80 m across, and travel a few kilometers before dissipating.

- The most extreme tornadoes can attain wind speeds of more than 480 km/h, are more than 3 km in diameter, and stay on the ground for more than 100 km.

- A tornado in El Reno, Oklahoma on May 31, 2013 was approximately 4.2 km wide, the widest on record

- The longest path length, in a tornado that affected parts of three US states (Missouri, Illinois, and Indiana) in March 1925, was on the ground continuously for 352 km. 695 people died and 2000 were injured.

- Average travel speed is 45 km/h but can vary a lot.

Downbursts and Microbursts

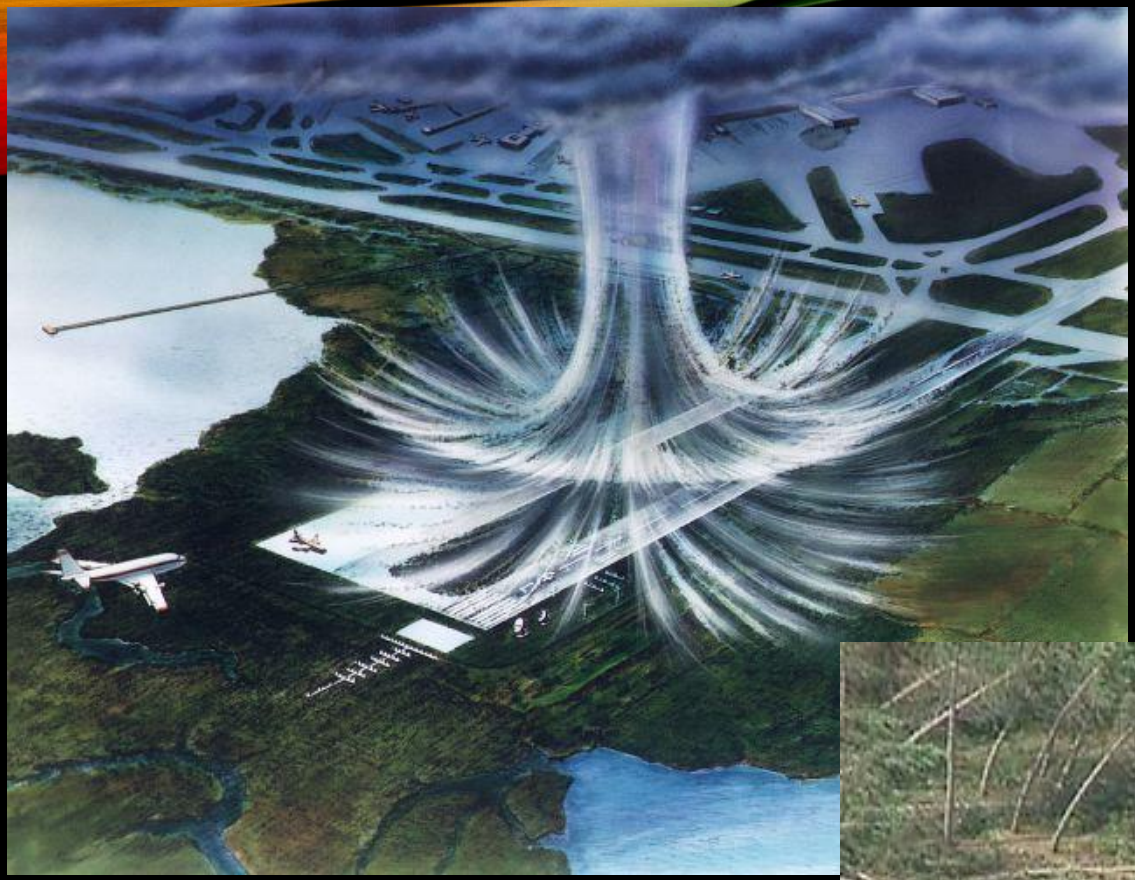
Downbursts are particularly strong downdrafts from thunderstorms.

- Dry downbursts - in air that is precipitation free or contains virga
- Wet downbursts - accompanied with precipitation

If they are less than 4 km in size (and most are) they can be called **microbursts**

A microburst can be particularly dangerous to aircraft, especially during landing, due to the wind shear caused by its gust front.

A microburst often has high winds that can knock over fully grown trees. They usually last for seconds to minutes.



- A downburst is created by a column of sinking air
- after hitting the ground , it spreads out in all directions
- capable of producing damaging winds of over 240 km/h
- often produces damage similar to that caused by tornadoes:
  - Downburst damage radiates from a central point as the descending column spreads out when hitting the surface
  - tornado damage more **convergent** consistent with rotating winds.
- the term **straight-line winds** is applied to damage from microbursts to help differentiate it from tornadoes.

WEATHER •

4:08pm, Oct 2

Cold air funnel spotted as wild storms hit southern Queensland

A cold air funnel seen from Warwick in Queensland's southern downs. Photo: ABC

ABC

A remarkable cold air funnel has been spotted over Warwick, south-west of Brisbane, on Tuesday afternoon as severe storms move east across parts of southern Queensland.

Weather Calendar September 2021 Waterspout off Mona Vale, Sydney

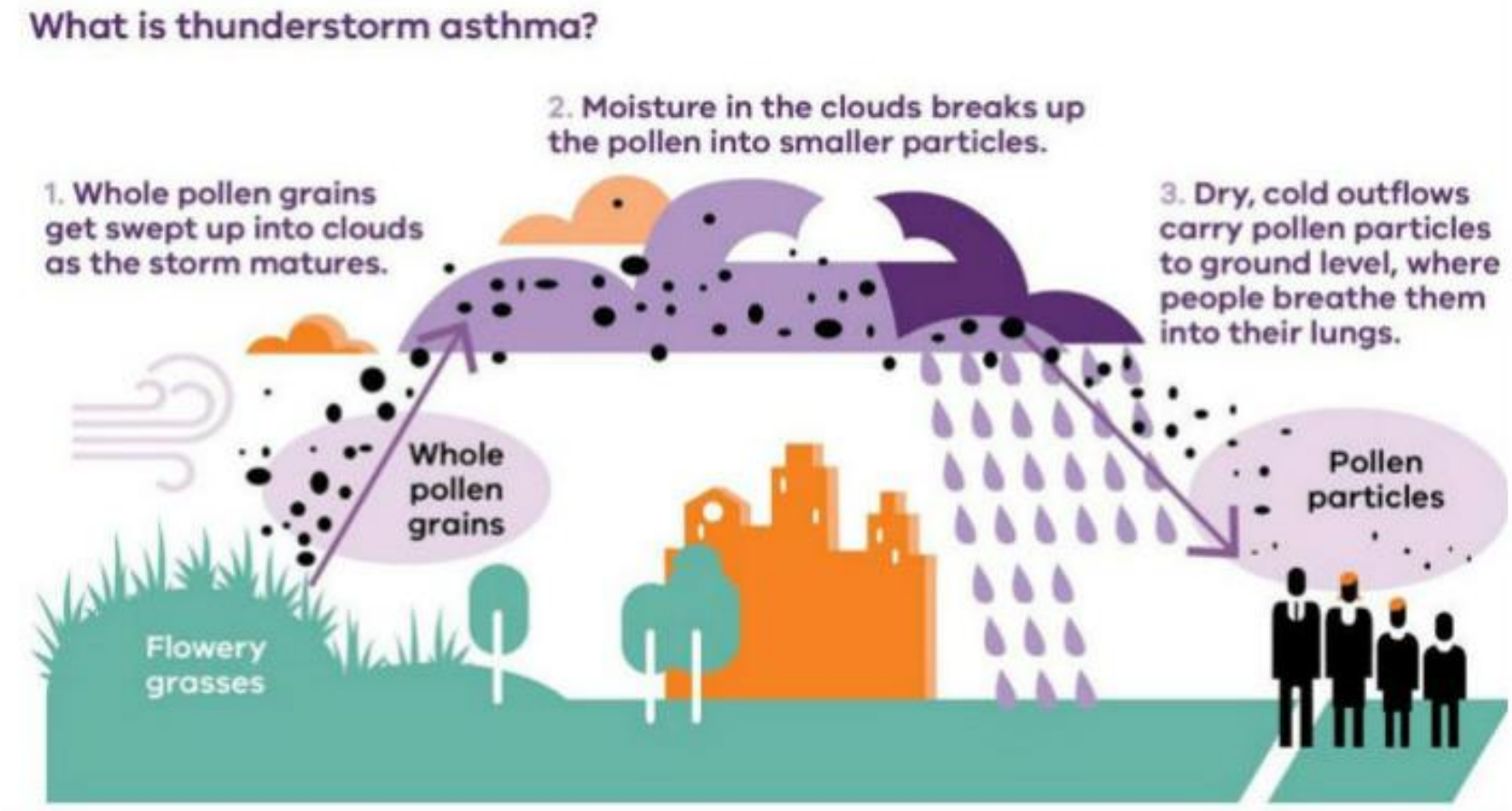
HEALTH

Thunderstorm asthma season is on now. Are we ready for another event if it happens during COVID-19?

ABC Health & Wellbeing / By science reporter Suzannah Lyons for the Health Report

Posted 9h ago, updated 44m ago

https://www.abc.net.au/news/health/2020-10-29/thunderstorm-asthma-event-in-covid-19/12795236



What causes thunderstorm asthma? *(Supplied: Department Of Health And Human Services Victoria)*

It's to do with a change in humidity and a drop in pressure.

Grass pollen gets sucked up into the storm as it's forming, and that's what then gets pushed down in the downdraft of the initial storm front and triggers most of the thunderstorm asthma.

The Science of Lightning

As rising ice particles in a cloud collide with water droplets and other ice particles, electronic charges are exchanged.

The result is **charge separation** in a cloud.

Negative charge at cloud base gathers positive charge at the surface.

Channel of negative charge descends toward the ground.

Lightning channel develops when negative charge reaches an object.

Lightning

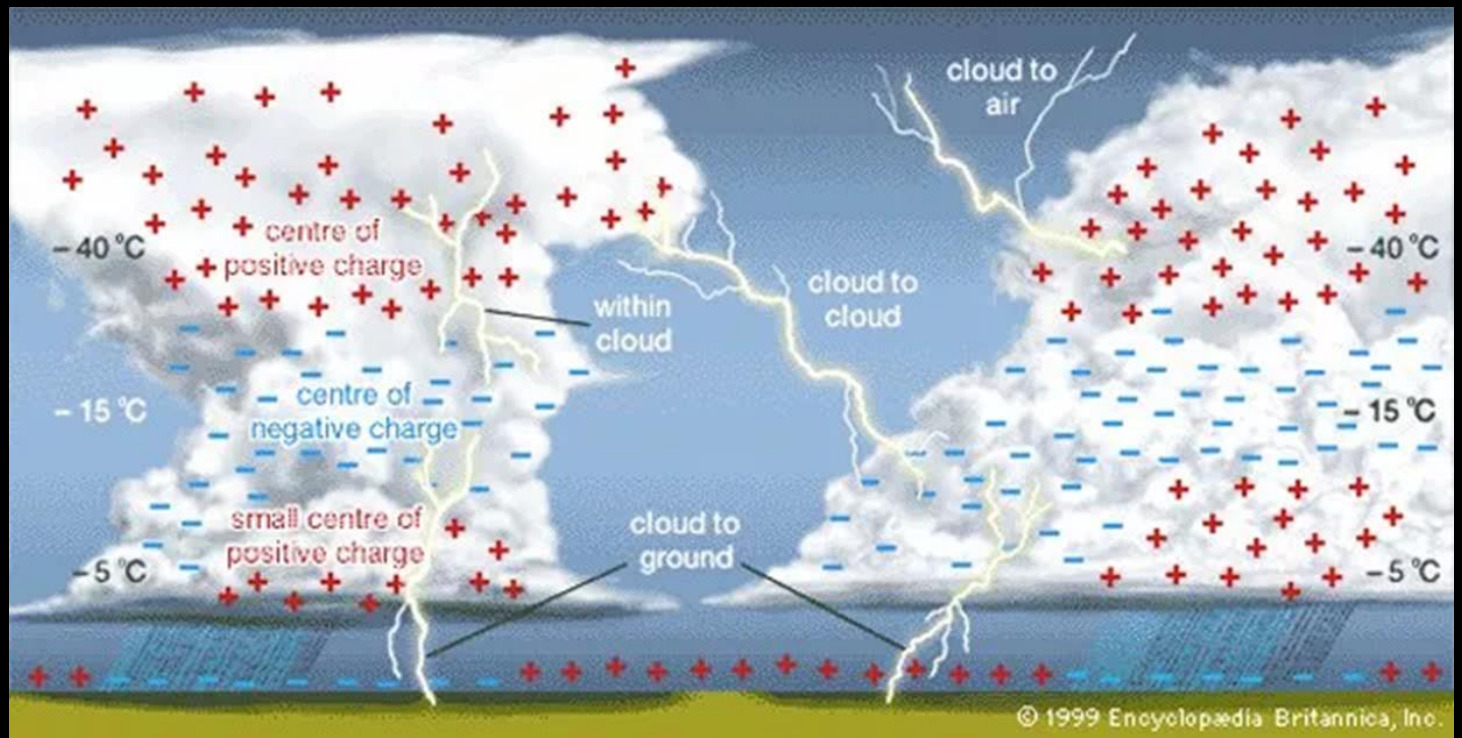
National Geographic

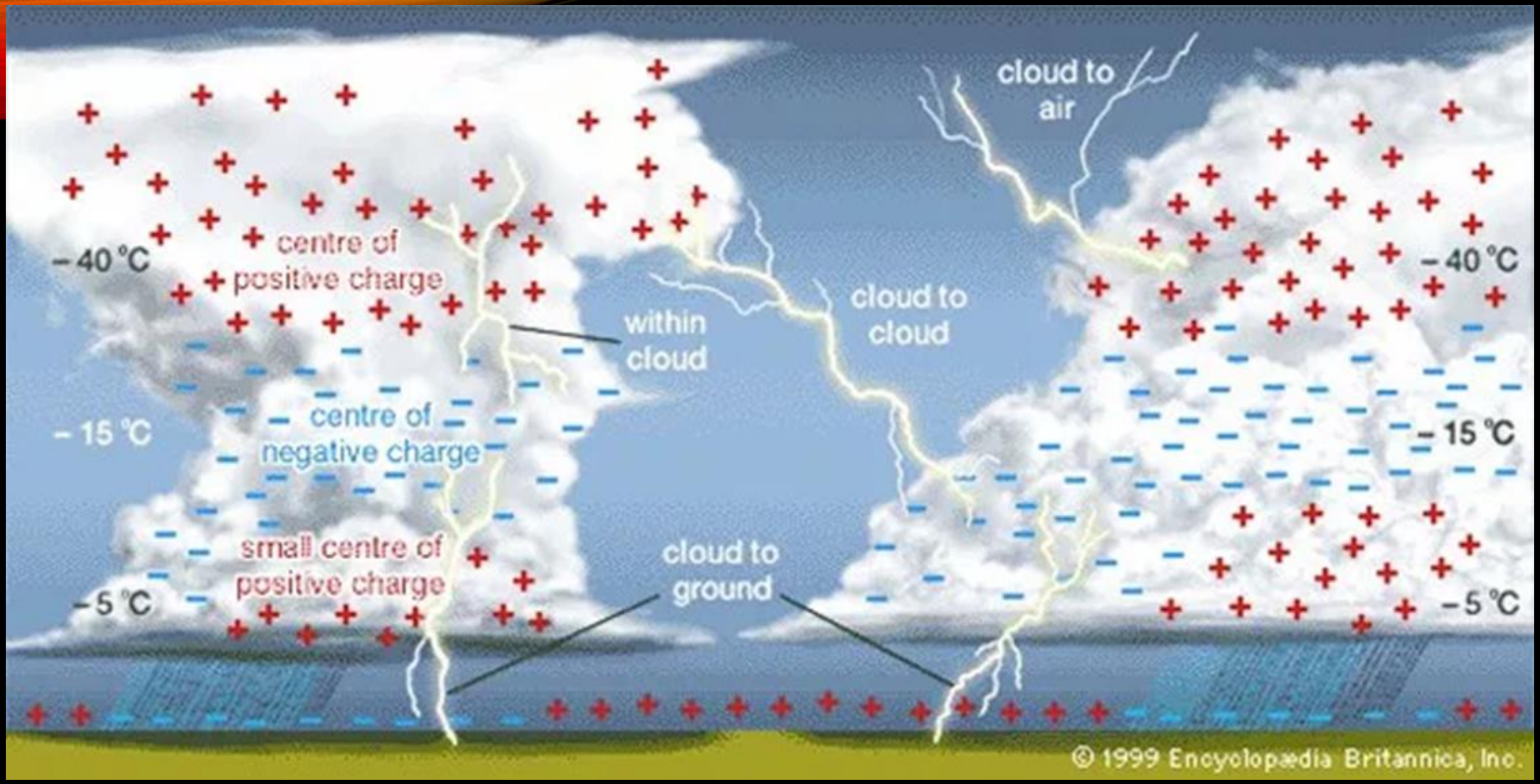
https://youtu.be/h-0gNl5f4BU

https://youtu.be/TWh440iSBqM

The Earth has an electric field. On average, this field points vertically downwards and it has a magnitude of about 100 Volts/meter. The Earth's surface carries a negative charge, while the upper atmosphere has a compensating positive charge.

Since the Earth's atmosphere is not a perfect insulator, there is a small current downwards. This would be enough to neutralise the Earth's negative charge and remove its electric field **if it were not for the effects of lightning**.



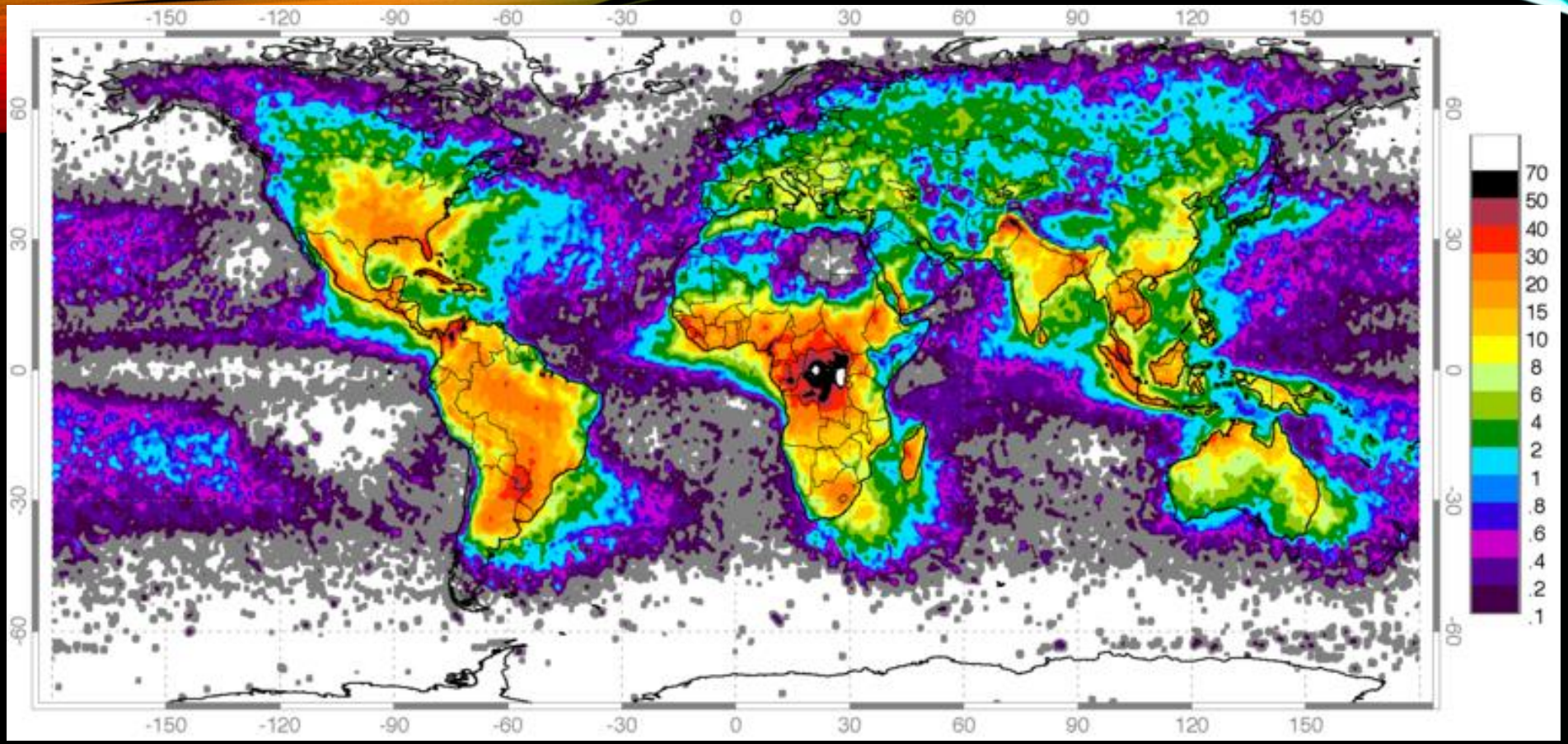


Below a thundercloud, the electric field points vertically upwards and is 50 times stronger than normal. Enough to make your hair stand on end!

http://www.feynmanlectures.caltech.edu/II_09.html

“It turns out that the bolts of lightning do not “discharge” the potential we have been talking about (as you might at first guess). Lightning storms carry *negative* charges to the earth. When a lightning bolt strikes, nine times out of ten it brings down negative charges to the earth in large amounts. It is the thunderstorms throughout the world that are charging the earth with an average of 1800 amperes, which is then being discharged through regions of fair weather.”

Over the entire surface, about 40,000 thunderstorms a day with about 4 million lightning flashes per day keep the Earth negatively charged, thus maintaining a relatively constant electric field.



Data from space-based sensors reveal the uneven distribution of worldwide lightning strikes. Units: flashes/km^2/yr.

Data obtained from April 1995 to February 2003 from NASA's Optical Transient Detector and from January 1998 to February 2003 from NASA's Lightning Imaging Sensor.

Do cosmic rays cause lightning?

Scientific American

January 24, 2008

January 2008

Joseph Dwyer, a professor of physics and space sciences at the Florida Institute of Technology, has been wondering the same thing.

Your question lies at the core of one of science's great mysteries: What causes lightning? Decades of electric field measurements made inside thunderstorms have failed to find large enough electric fields to cause a spark, even when the effects of precipitation are taken into account. Since we know that lightning does occur—in fact, it strikes the earth about four million times a day—we must be missing something in our understanding.

A mechanism proposed by Russian physicist Alex V. Gurevich of the Lebedev Physical Institute and his collaborators suggest that the movement of large showers of energetic particles produced by high-energy cosmic rays—which originate from exploding stars halfway across the galaxy—might provide a conductive path that initiates lightning. There are indeed types of particle detectors called spark chambers that exploit this principle. In a spark chamber, a very large voltage is applied across a

... one of science's great mysteries: what causes lightning?

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