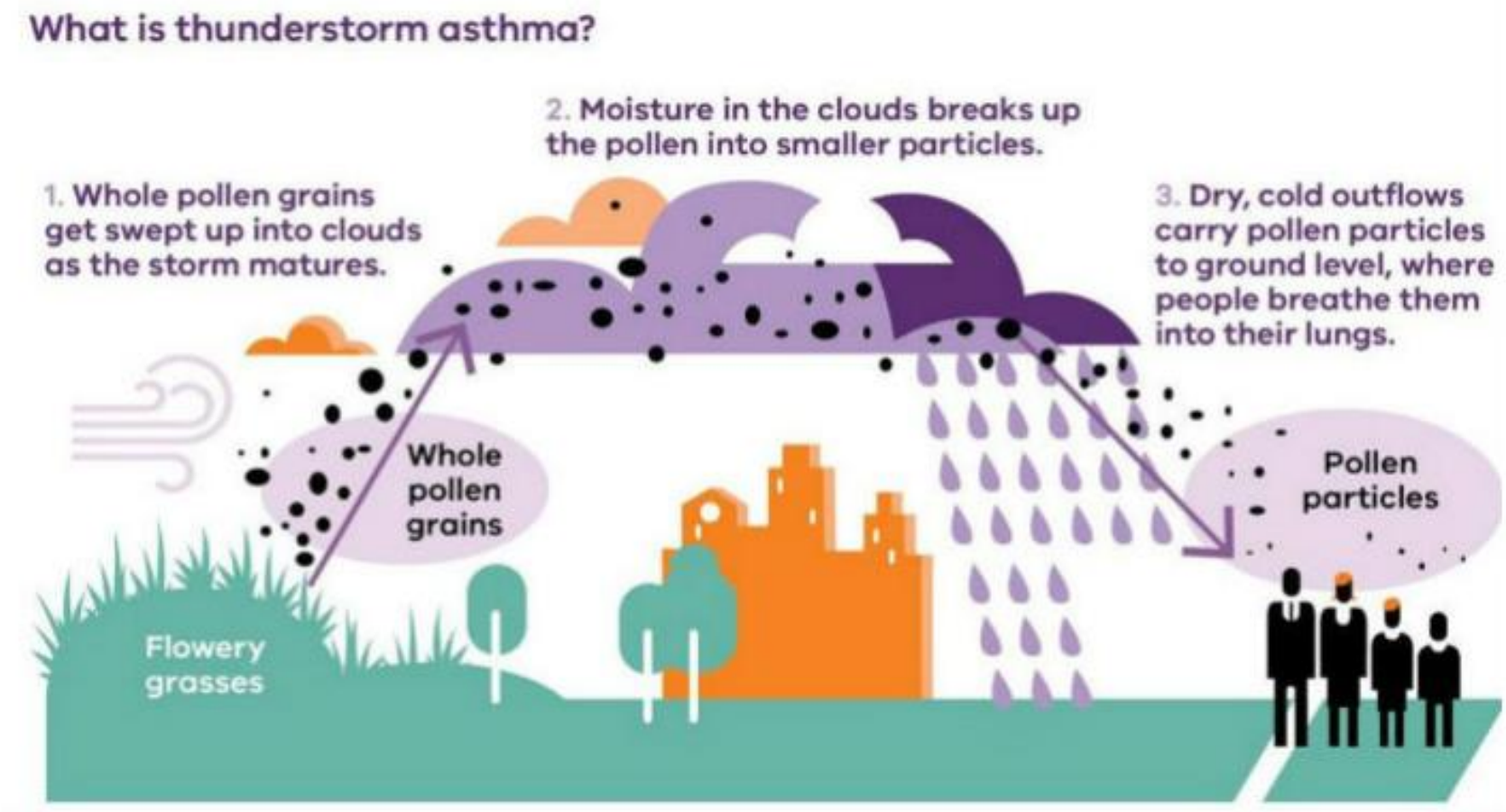
Understanding weather and the weather forecast

Week 24

Lightning and Tropical Cyclones

Terry Hart



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.

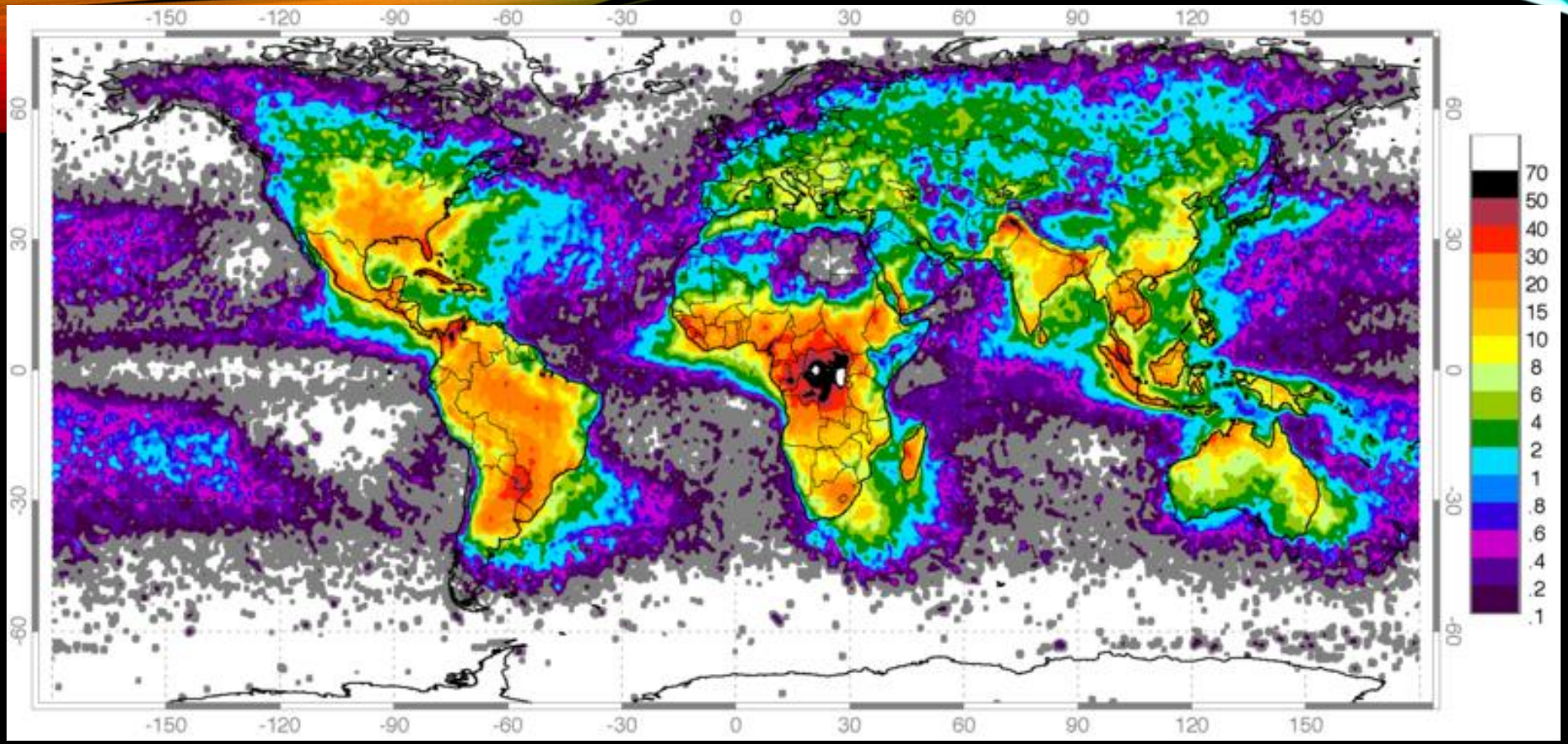
Negative charge at cloud base gathers positive charge at the surface.

Channel of negative charge descends toward the ground.

Lightning channel develops when negative charge reaches an object.

Weather wise videos

Lightning https://www.youtube.com/watch?v=9K-v-RJ-z2A



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.

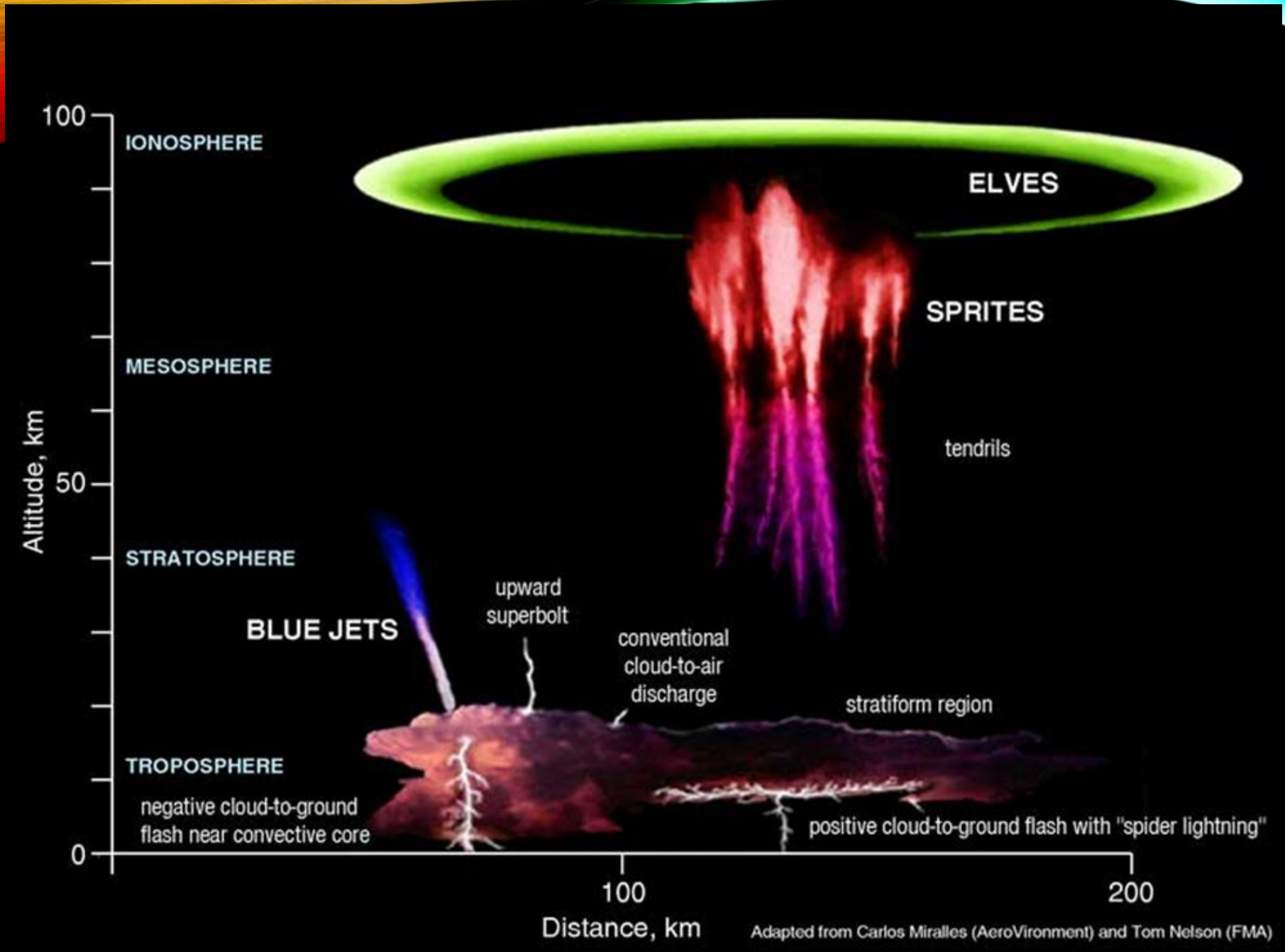
A mechanism proposed by Russian physicist Alex V. Gurevich of the Lebedev Physical Institute and his collaborators suggest that the movement of large showers of energetic particles produced by high-energy cosmic rays—which originate from exploding stars halfway across the galaxy—might provide a conductive 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?

CONSERVATION
Double Whammy of W
Overfishing Could Spel
Antarctic Krill
15 hours ago — Chelsea Harvey a

NATURAL DISASTERS
One Climate-Change W
in the Dark
19 hours ago — Jane Braxton Litt

ENGINEERING
New Bio-Inspired Mole
Concrete Resist Freeze
21 hours ago — Sophie Bushwick


100
IONOSPHERE
ELVES
SPRITES
MESOSPHERE
tendrils
Altitude, km
50
STRATOSPHERE
upward
superbolt
BLUE JETS
conventional
cloud-to-air
discharge
stratiform region
TROPOSPHERE
negative cloud-to-ground
flash near convective core
positive cloud-to-ground flash with "spider lightning"
0
100
200
Distance, km
Adapted from Carlos Miralles (AeroVironment) and Tom Nelson (FMA)

Other phenomena associated with atmospheric electricity

Sprites

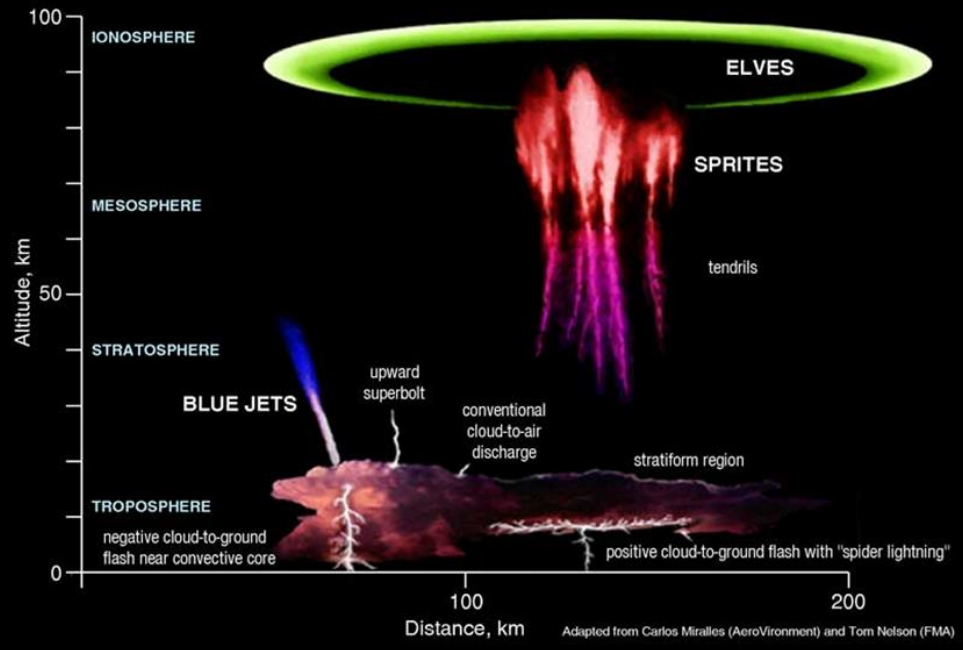
Large-scale electrical discharges that occur high above thunderstorm clouds, or cumulonimbus, giving rise to a quite varied range of visual shapes flickering in the night sky.

https://en.wikipedia.org/wiki/Sprite_(lightning)

Blue Jets

Ball lightning

Gamma Ray bursts

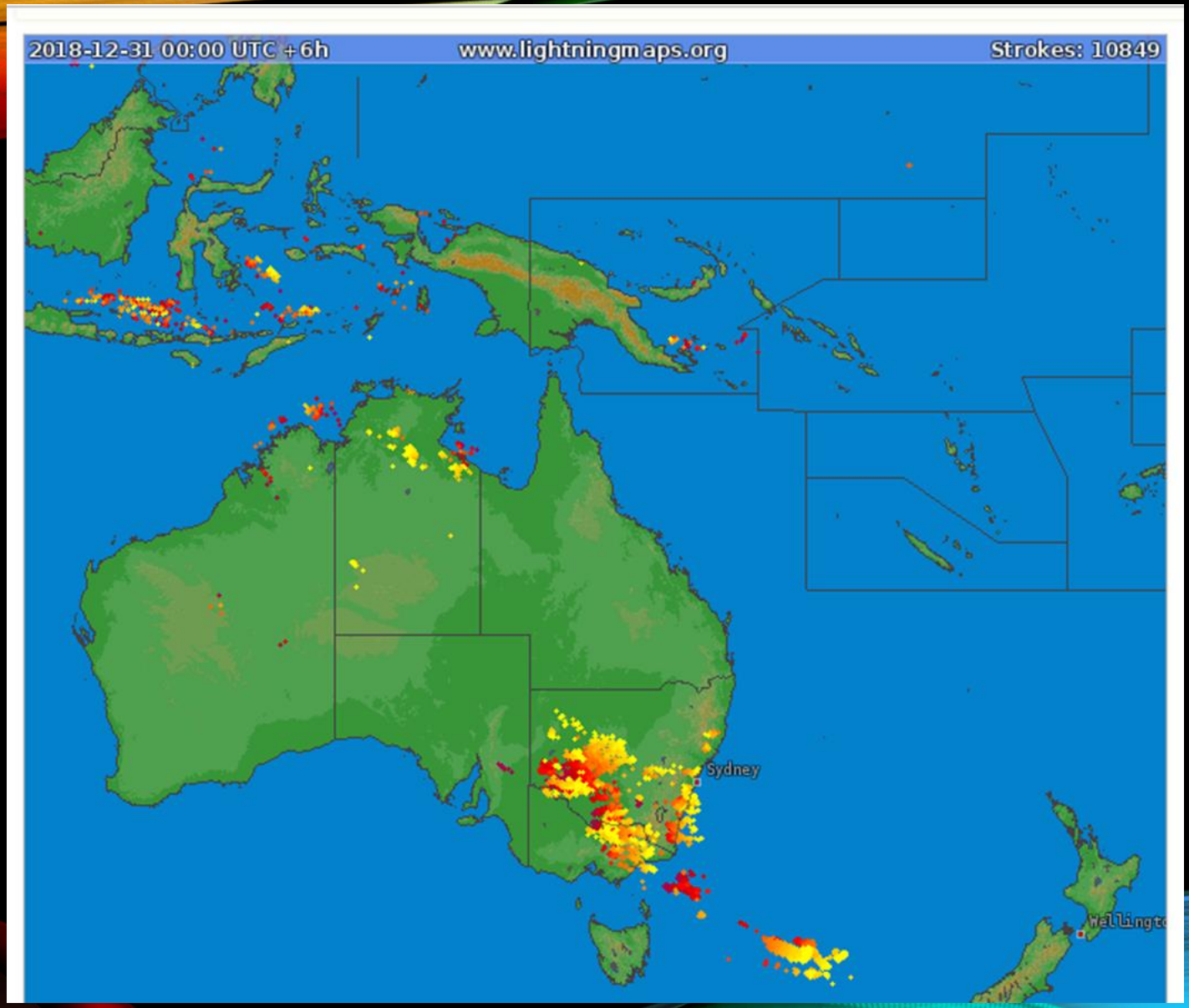


Gamma Ray bursts from the top of thunderstorms.

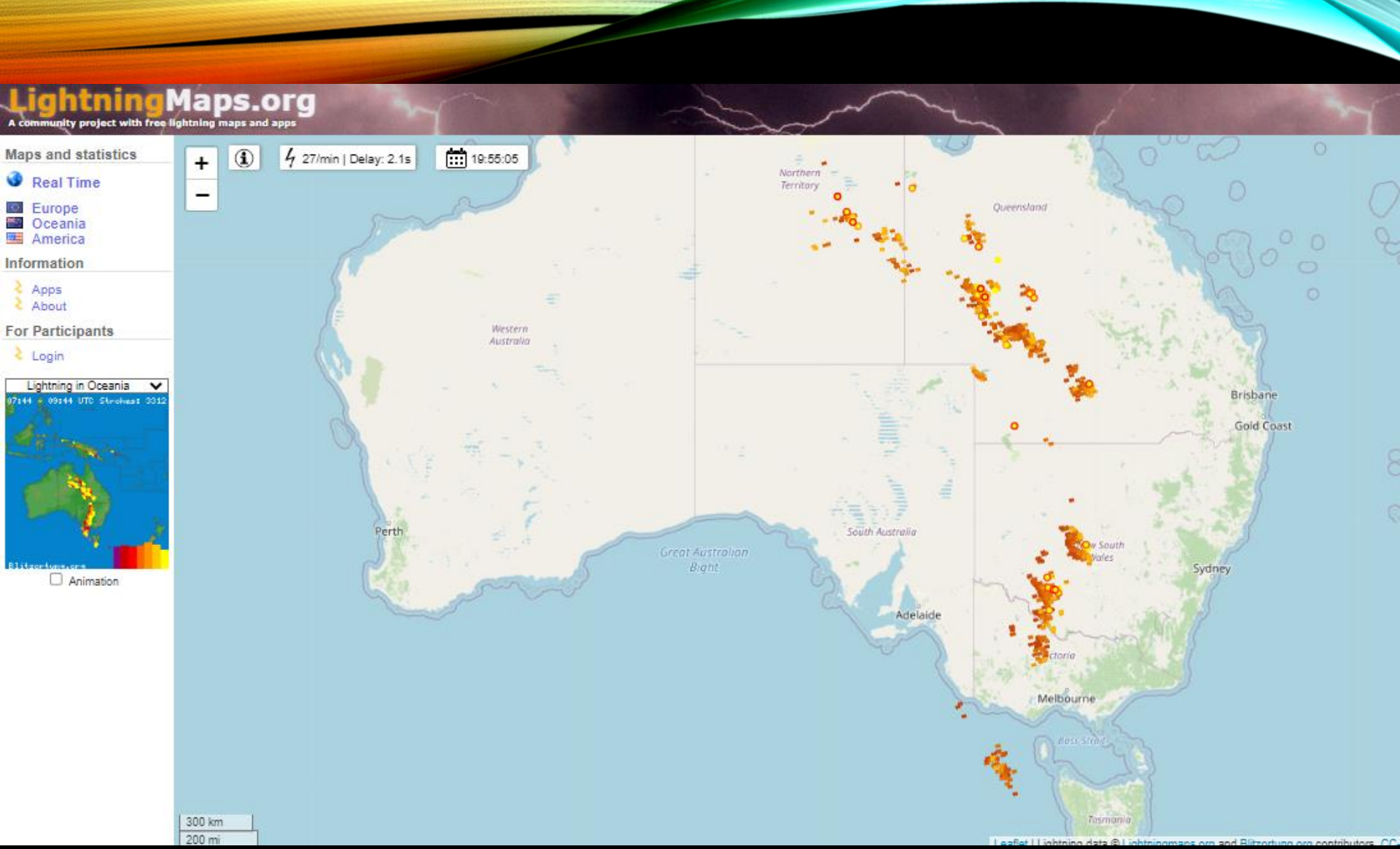
First detected in 1994

The satellite-based Fermi Gamma-ray Burst Monitor results show that gamma rays and antimatter particles (positrons) can be generated in powerful thunderstorms. It is suggested that the antimatter positrons are formed in terrestrial gamma-ray flashes (TGF).

TGFs are brief bursts occurring inside thunderstorms and associated with lightning. The streams of positrons and electrons collide higher in the atmosphere to generate more gamma rays. About 500 TGFs may occur every day worldwide, but mostly go undetected. *(Wikipedia – thunderstorms)*



https://www.lightningmaps.org/



8pm Monday 29 August 2022

Lightning Safety

https://www.cdc.gov/disasters/lightning/safetytips.html

Indoors:

- Avoid water
- Don’t touch electronic equipment
- Avoid windows, doors, porches, and concrete
- Don’t use corded phones.

Outdoors:

Go indoors (“When thunder roars, go indoors”)
Seek shelter immediately, even if caught out in the open
Separate from others
Don’t stay in open vehicles or open structures
Don’t stay near tall structures

If caught out in the open, crouch down.

The "30-30" rule - play should stop when the 'flash-to-bang' count is 30 seconds and should not resume until 30 minutes after the last lightning.

AFLOAT September 2022 No. 389

Photo: Colin Kenworthy Broome Sea Rescue

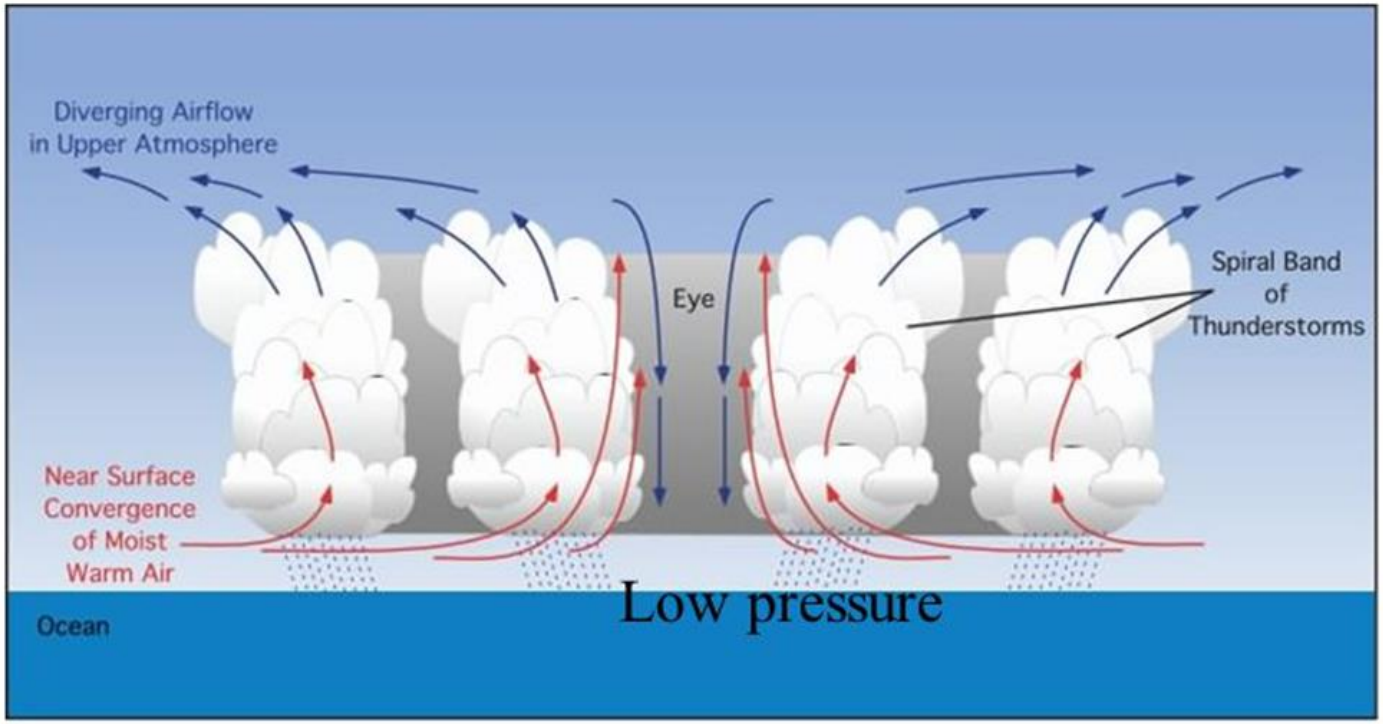
Lucky trio holding the remains of their impromptu lightning rod.

Some fishermen near Broome got caught out in a thunderstorm in open water. They deliberately left the fishing rod in its holder to act as a lightning rod and it worked. The lightning strike went through the fishing rod, destroying the rod and reel.

Tropical Cyclones

- Form from an active thunderstorm area in a weak low pressure area
- Under favourable circumstances these narrow towers can mutually reinforce and combine into a large cyclone
- The wind accelerates into the centre of the weak low and spin faster due to conservation of angular momentum (Coriolis Effect).
- Convergence produces even more lifting - leading to more thunderstorms and rainfall
- Pressure continues to fall – so a feedback cycle is set up.

High relative humidity required: one of the most important ingredients to form hurricanes is the release of latent heat to the atmosphere

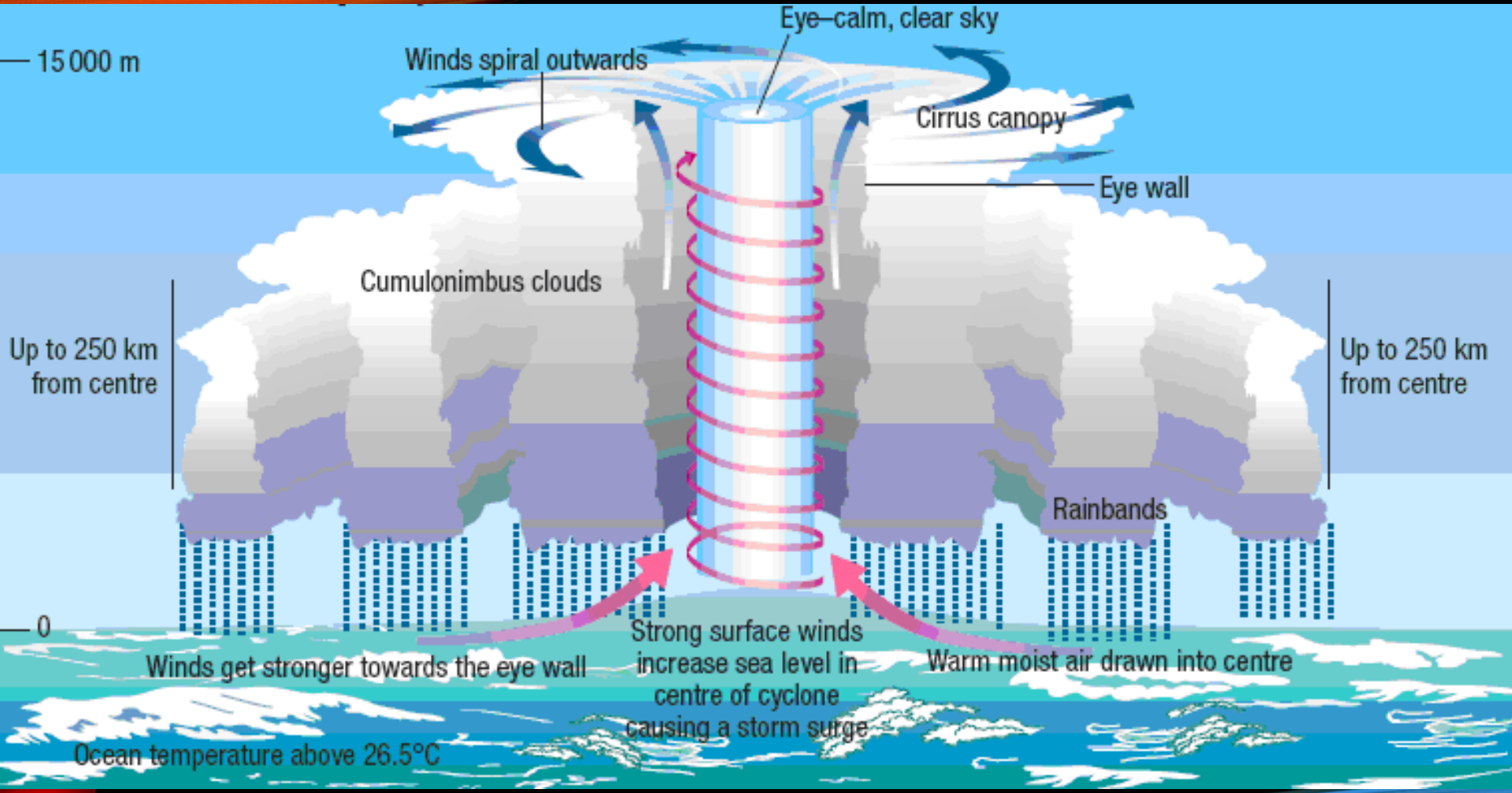


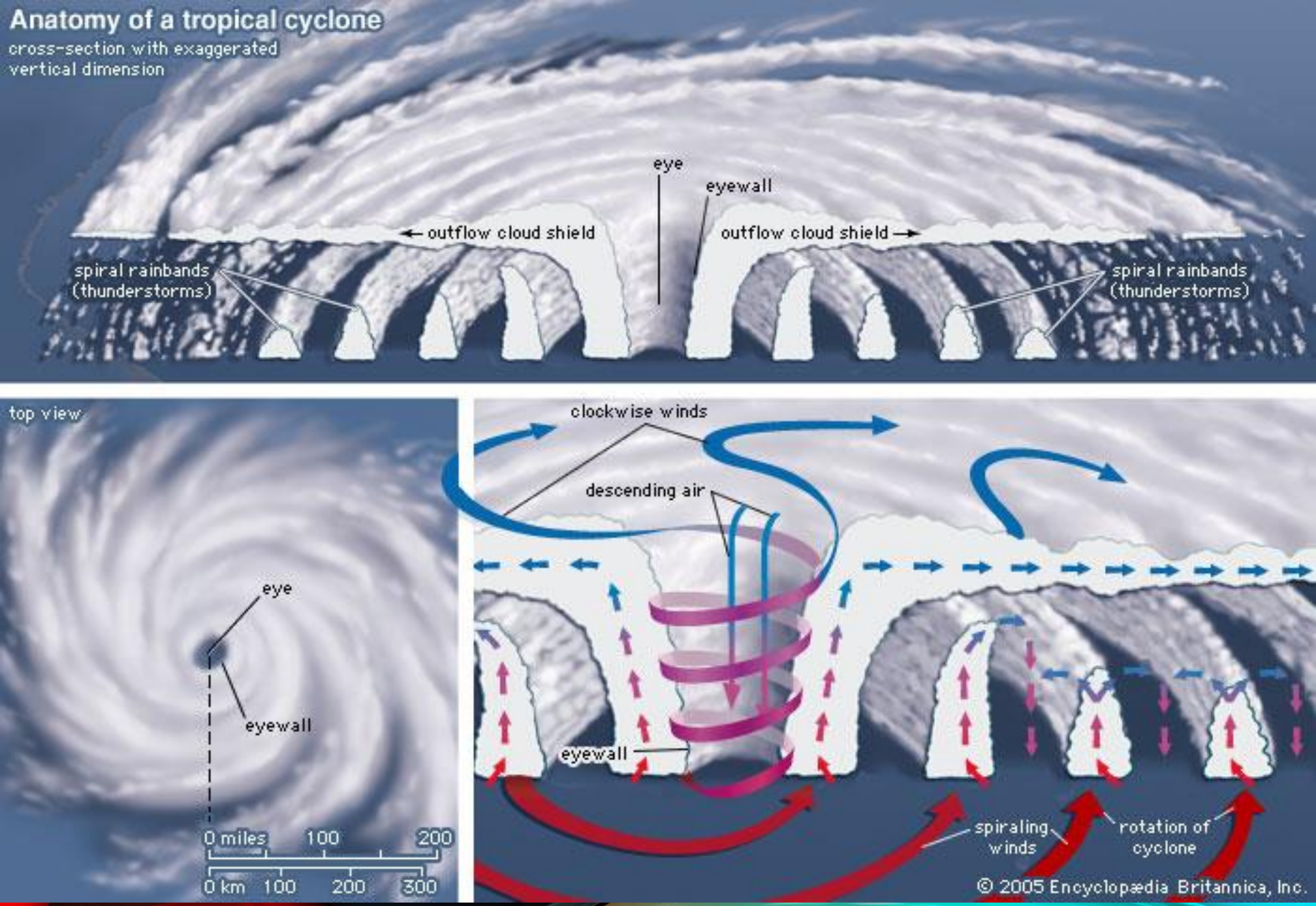
- Latent heat released due to condensation warms the atmosphere and cause the decrease of pressure at surface

- As sea level pressure decreases, more air converges at the center of the storm, more latent heat is released and the storm becomes stronger and more powerful, with increasing winds

The eye of the cyclone

- The winds reach a limit that can be generated by the amount of latent heating, so an eye forms.
- Limit about 320 km/h
- Weather in the eye is normally calm and free of clouds
- The eye is normally circular, 30–65 km in diameter, but can be as small as 3 km and as large as 370 km.
- The cloudy outer edge of the eye is called the "eyewall". The eyewall typically expands outward with height, resembling an arena football stadium
- The eyewall is where the greatest wind speeds are found, air rises most rapidly, clouds reach their highest altitude, and precipitation is the heaviest. The heaviest wind damage occurs where a tropical cyclone's eyewall passes over land. (**radius of maximum winds**).


15 000 m
Eye–calm, clear sky
Winds spiral outwards
Cirrus canopy
Eye wall
Cumulonimbus clouds
Up to 250 km from centre
Up to 250 km from centre
Rainbands
0
Winds get stronger towards the eye wall
Strong surface winds increase sea level in centre of cyclone causing a storm surge
Warm moist air drawn into centre
Ocean temperature above 26.5°C



Beware: northern hemisphere diagram!

Conditions for tropical cyclones to form:

- Sea Surface Temperature greater than 26.5 degrees
- Moist unstable atmosphere
- Light winds at surface that do not increase much with altitude (strong wind shear can blow the system apart)
- Far enough from Equator for Coriolis effect:
  5-10 degrees North and South.

Decay of Cyclones:

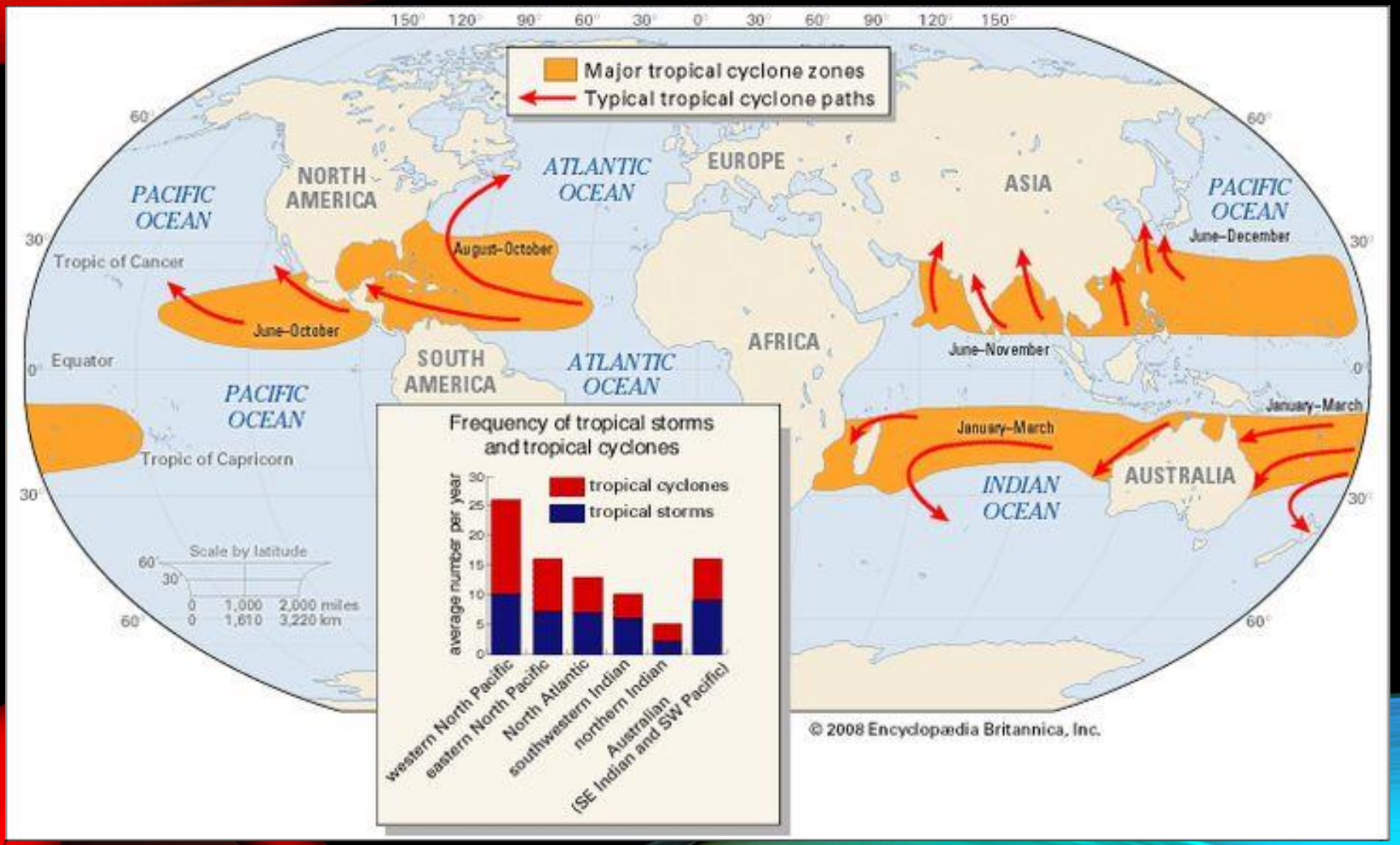
- Move into area of strong upper winds
- Move over colder waters
- Move over land – friction and fuel source (water vapour) are cut off.

What is the difference between Hurricanes, Typhoons and Tropical Cyclones?

https://youtu.be/2F1RrGwp_go

What about a tornado?

https://youtu.be/W0LskBe_QfA


Major tropical cyclone zones
Typical tropical cyclone paths
PACIFIC OCEAN
NORTH AMERICA
ATLANTIC OCEAN
EUROPE
ASIA
PACIFIC OCEAN
Tropic of Cancer
August–October
June–October
June–December
Equator
SOUTH AMERICA
ATLANTIC OCEAN
AFRICA
June–November
PACIFIC OCEAN
Tropic of Capricorn
January–March
January–March
INDIAN OCEAN
AUSTRALIA
Scale by latitude
0 1,000 2,000 miles
0 1,610 3,220 km
Frequency of tropical storms and tropical cyclones
tropical cyclones
tropical storms
average number per year
western North Pacific
eastern North Pacific
North Atlantic
southwestern Indian
northern Indian
Australian (SE Indian and SW Pacific)
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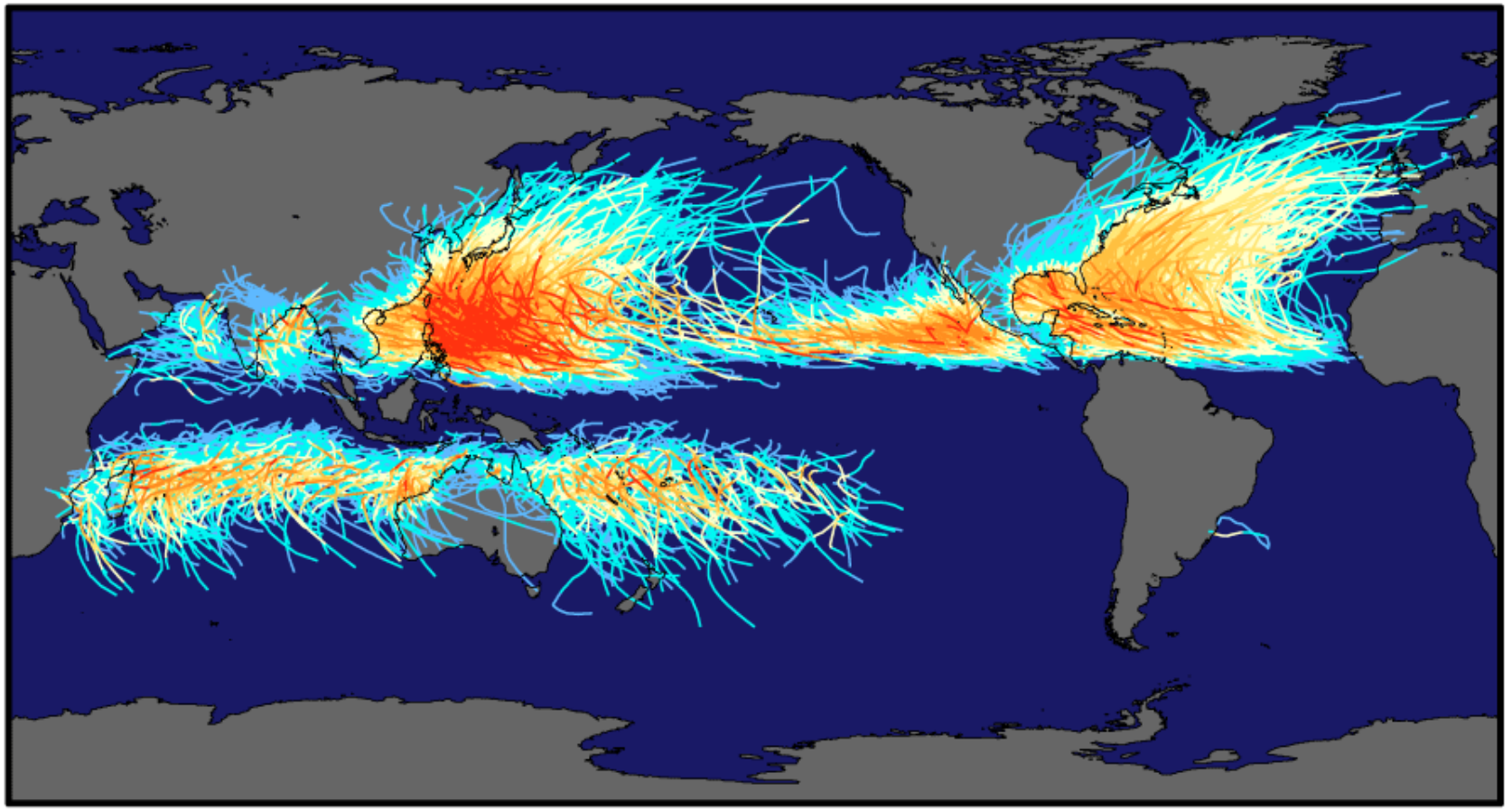
Tracks and Intensity of All Tropical Storms



Saffir-Simpson Hurricane Intensity Scale

https://eoimages.gsfc.nasa.gov/images/imagerecords/7000/7079/tropical_cyclone_map_lrg.gif

(up to 2006)

NATIONAL HURRICANE CENTER and CENTRAL PACIFIC HURRICANE CENTER

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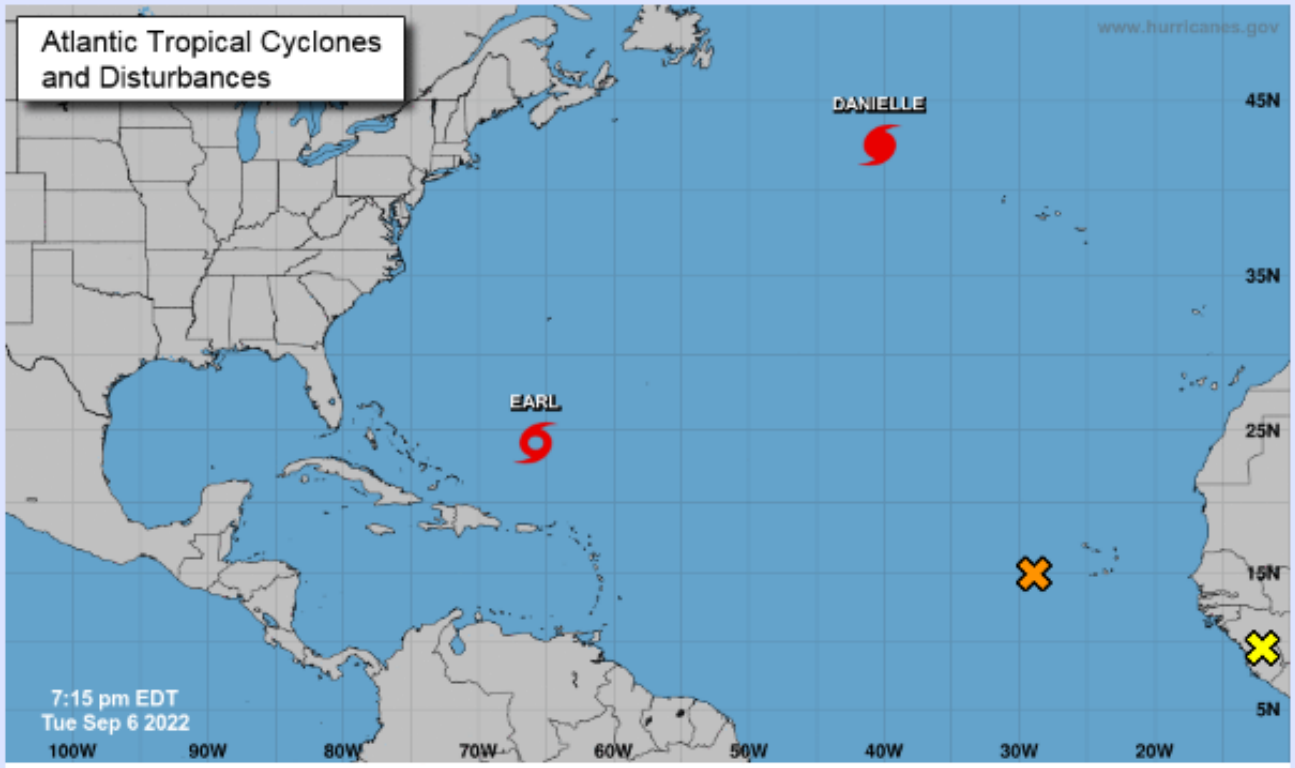
Top News of the Day... *view past news*

Last update Tue, 6 Sep 2022 23:42:52 UTC

- NHC issuing advisories for the Atlantic on TS Earl and Hurricane Danielle
- NHC issuing advisories for the Eastern Pacific on Hurricane Kay
- Marine warnings are in effect for the Atlantic, Caribbean/SW Atlantic and Eastern Pacific
- Key Messages regarding Hurricane Kay
- Hurricane Andrew at 30: Where science has taken us
- The National Hurricane Center Storm Surge Unit has released Version 3 of the Storm Surge Risk Maps

Central Pacific | Eastern Pacific | Atlantic



https://www.nhc.noaa.gov/

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Last update Tue, 6 Sep 2022 23:45:21 UTC

- NHC issuing advisories for the Atlantic on TS Earl and Hurricane Danielle
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