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METEOROLOGY FOR AUSTRALIA

CHAPTER 26 – DUST DEVILS AND TORNADOES

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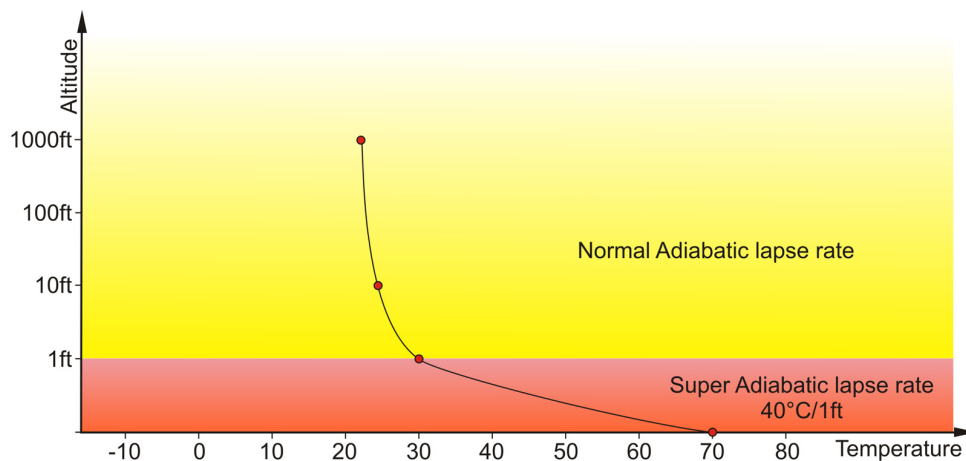
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DUST DEVILS, TORNADOES AND WATERSPOUTS

DUST DEVILS

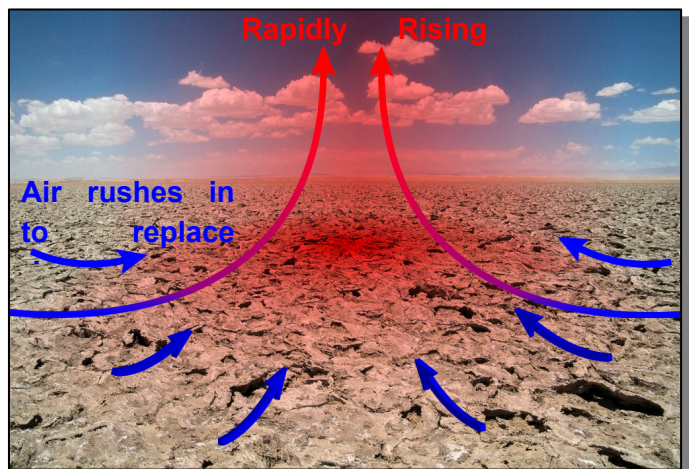
Dust devil formation requires strong surface heating for some hours with little surface wind. This results in localised heating with the ground becoming extremely hot.

The ground temperatures may be 60°C or 70°C but with a temperature of only approximately 30°C one foot above the ground. This is called a “super adiabatic lapse rate” and is extremely unstable. (It is important to realise that this “super adiabatic lapse rate” only exists for a metre or so above the ground).



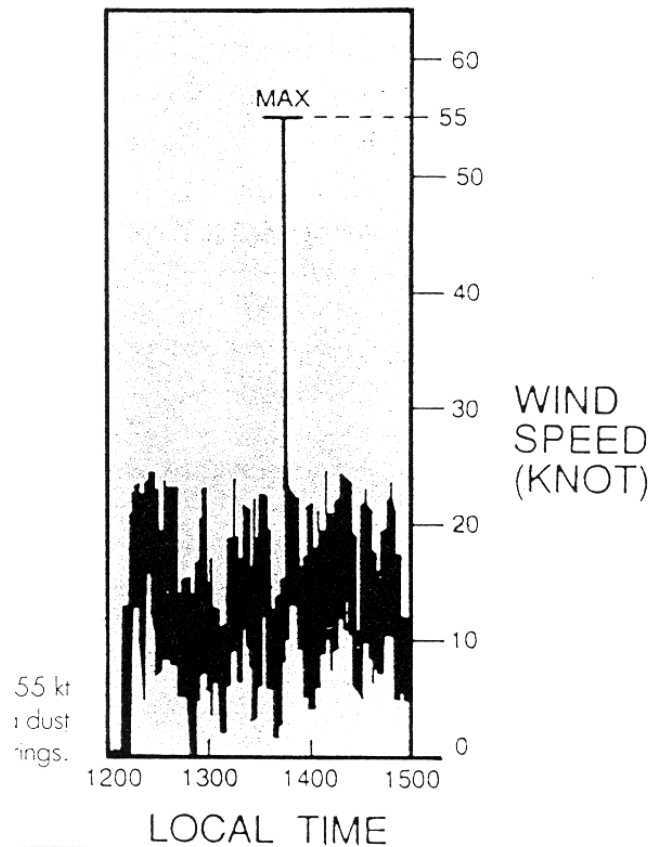
Super Adiabatic Lapse Rate

A parcel of rising air will rise and cool at the DALR, not at the ELR. The parcel of air is much hotter and much less dense than the surrounding air and rises quickly. When the parcel of air rises quickly, air rushes in from all directions to replace the rising air. Rotation will occur (in either direction, at random) and the velocity of the rotating air will increase rapidly due to the Conservation of Angular Momentum. Because of the relatively small cross section and short life of the rotating column, Coriolis Force is not a significant factor. Depending on external disturbances to the in-flowing air during the initial stages of the Dust Devil formation, rotation may be in **either** direction.



An Area of Extreme Local Heating

A rapidly rotating wind in which there is an imbalance between Cyclotrophic Force and Pressure Gradient Force is called a “Super Geostrophic Wind”. Dust Devils mostly occur in the summer and in early autumn. Severe gusts resulting from dust devils may result in the temporary loss of control in light aircraft and light aircraft pilots are advised to remain clear of these phenomena.



Wind Associated with a Dust Devil at Alice Springs

TORNADOES

Tornadoes are violent whirlwinds mostly occurring in the USA, but can occur anywhere where severe thunderstorms are found.

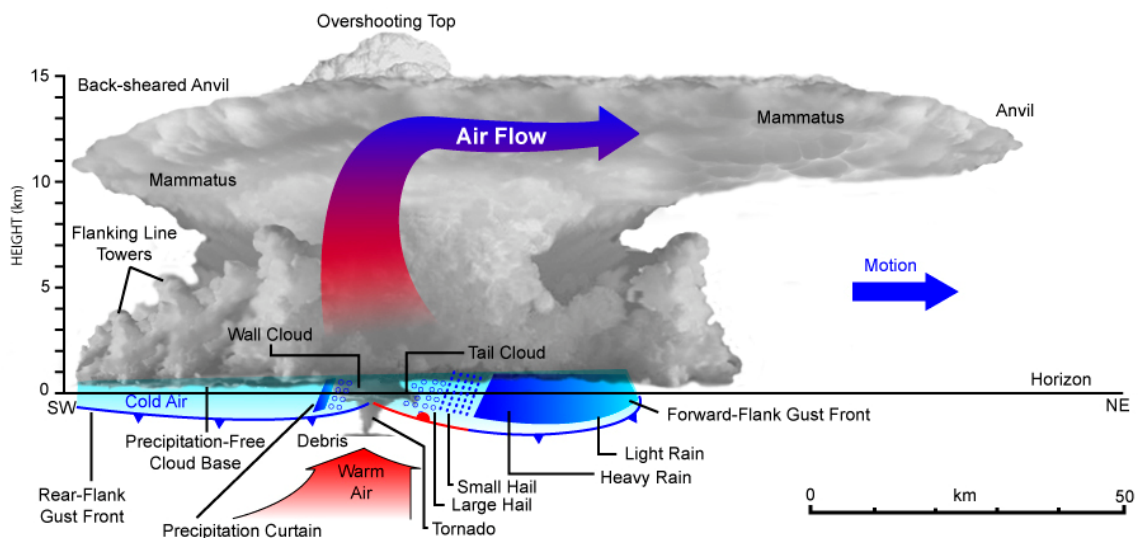
They form in association with Cbs, (particularly the ‘Super Cell’ thunderstorms often found in the USA) which require for their generation a lot of moisture, instability, middle-level windshear and a trigger. This trigger would normally be an area of intense local heating or other uplift. The subsequent mechanics of tornado formation are complex, but the cyclotrophic winds created by a tornado could be in the order of 150 kts.



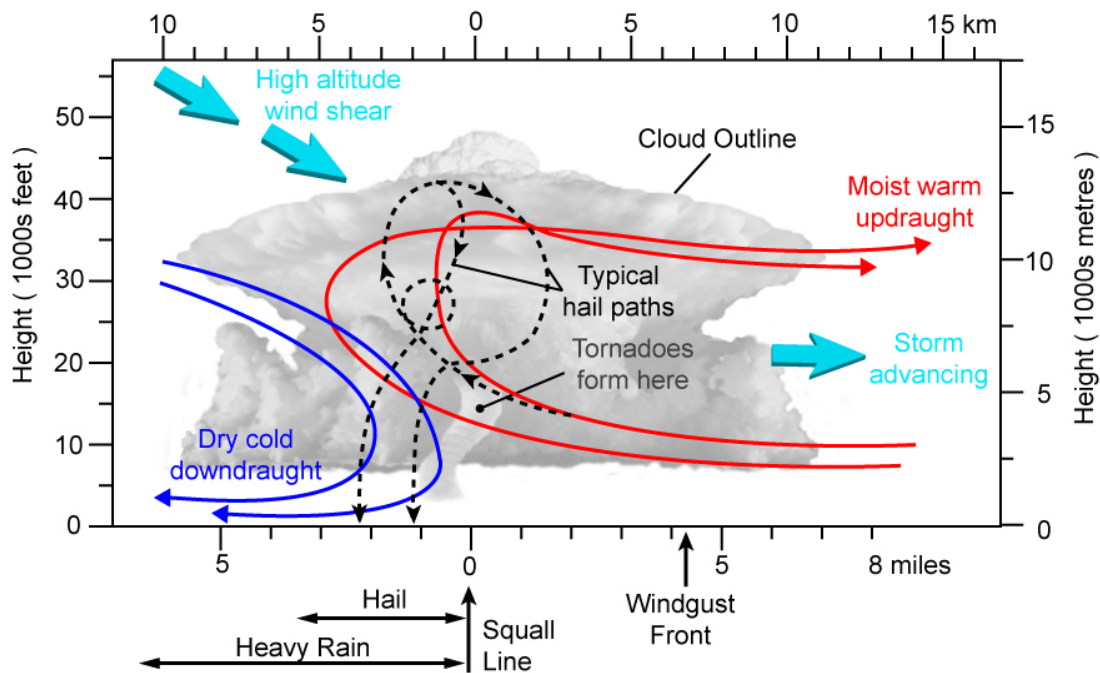
The vertical extent of a tornado is only likely to be a few hundred feet, and its eye or base from only a matter of metres to more than one kilometre wide, so the damage it causes is only over a relatively narrow area. The intense depression within the tornado causes adiabatic cooling of the moist air, so a funnel can be seen between the Cb and the surface. It is also this intense low pressure which causes a lot of damage as the pressure changes on the passage of a tornado can literally cause buildings to explode.

The exact tornado mechanism is still not fully understood because of the observational problems involved. Tornadoes generally develop on the periphery (often the Rear Flank Downdraft section) of a severe rotating thunderstorm system where horizontal convergence increases the vorticity and rising air is replenished by moist air from progressively lower levels as the vortex descends and intensifies.

The rapidly rising air in the vortex causes a rapid removal of air from the spire and creates a violent pressure decrease at the surface. The pressure drop is estimated to exceed 200-500hPa in some cases. It is this pressure drop which makes the funnel visible by causing air entering the vortex to cool and reach saturation. The vortex is usually only a few hundred metres in diameter and the winds around the core can attain speeds of 100–200kts.



A Super Cell Thunderstorm



Thunderstorm structure with hail and tornado formation

WATERSPOUTS



Waterspouts are tornadoes that form over water (usually the sea). They tend not to be as violent as overland tornadoes because local heating is not as extreme. The funnel is usually very obvious as there is water from the sea being ingested at the base, as well as the normal adiabatic condensation occurring. Although less intense than their overland counterpart, they can still create extreme turbulence.