

# The Vortex Engine

**The utilization of updraft systems to increase rainfall,  
reduce global warming and generate electrical power**

Presentation by Don Cooper CPEng

Bunbury, Western Australia

# First the Vortex Engine's cousin - the Solar Updraft Tower

## Solar Chimney



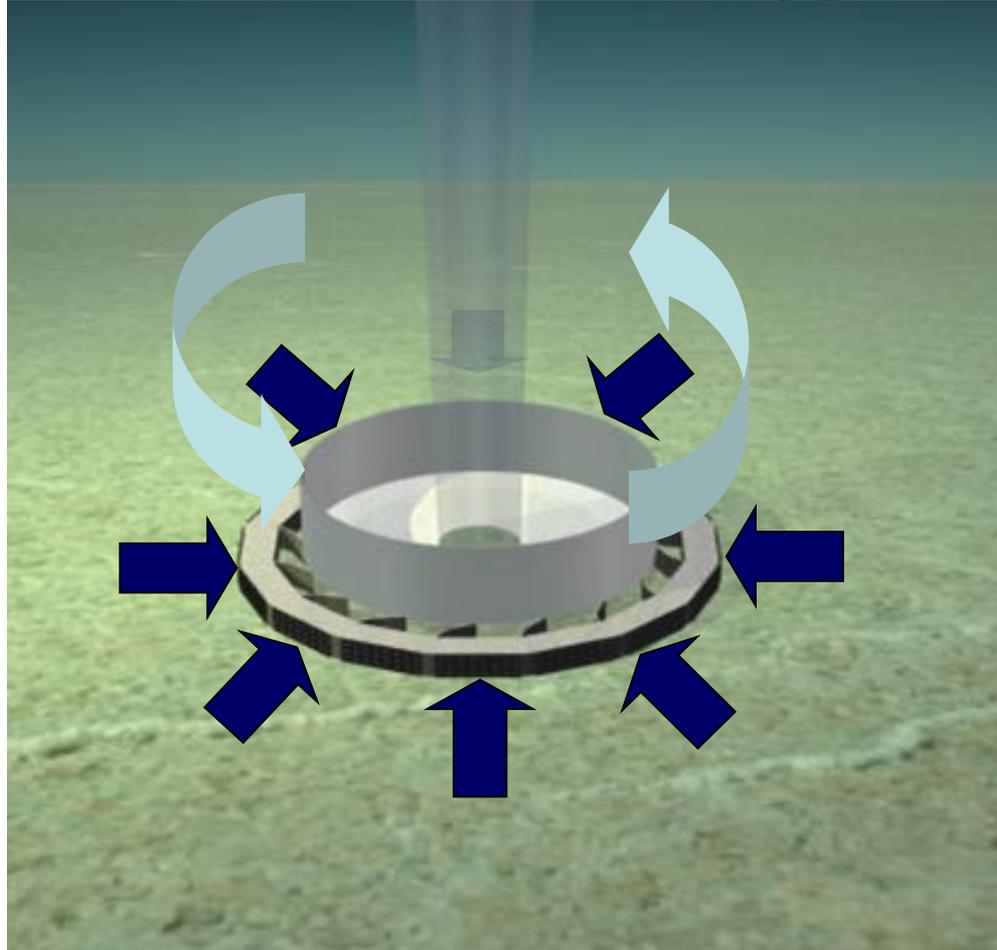
Manzanares  
200 m high, 10 m diameter  
Collector 0.04 sq. km  
50 kw, 130 J/kg, 1 Mg/s  
Spain 1982 to 1989



Enviromission  
1000 m high, 100 m diameter.  
Collector 40 sq km  
200 MW, 300 tonne/sec  
Australia / US 2008

**Enviromission in Australia and Solarmission in the US are planning to build a 200 MWe solar-thermal power station**

# The Vortex Engine



The vortex chimney should be regarded as a natural “tunnel” which is able to link the high and low temperature strata of the Troposphere, thereby releasing the energy in atmospheric water vapor.

# The Increase in Atmospheric Water Vapour Content

The increase in atmospheric CO<sub>2</sub> content has been well documented. Not so for the much more important greenhouse gas – water vapour:

*“When you heat the planet, you increase the ability of the atmosphere to hold moisture. The atmosphere’s water vapor content has increased by about 0.41 kilograms per square meter (kg/m<sup>2</sup>) per decade since 1988, and natural variability in climate just can’t explain this moisture change. The most plausible explanation is that it’s due to the human-caused increase in greenhouse gases.”*

Benjamin Santer, lead author from Lawrence Livermore National Laboratory’s Program for Climate Modelling and Intercomparison.

Water vapor strongly amplifies the warming effect of increased atmospheric levels of carbon dioxide. This is a “positive feedback loop.”

**By conveying water vapor to the top of the Troposphere, the Vortex Engine and to a much lesser extent the Solar Updraft Tower can act to reduce atmospheric water vapor levels by “freeze drying” the atmosphere.**

**The runaway Greenhouse Effect  
**must** be halted**

**We have to reverse the growth in  
atmospheric CO<sub>2</sub> and water vapor**

**The Vortex Engine can arguably go  
a considerable way towards  
achieving this**

# **The Solar Updraft Tower**

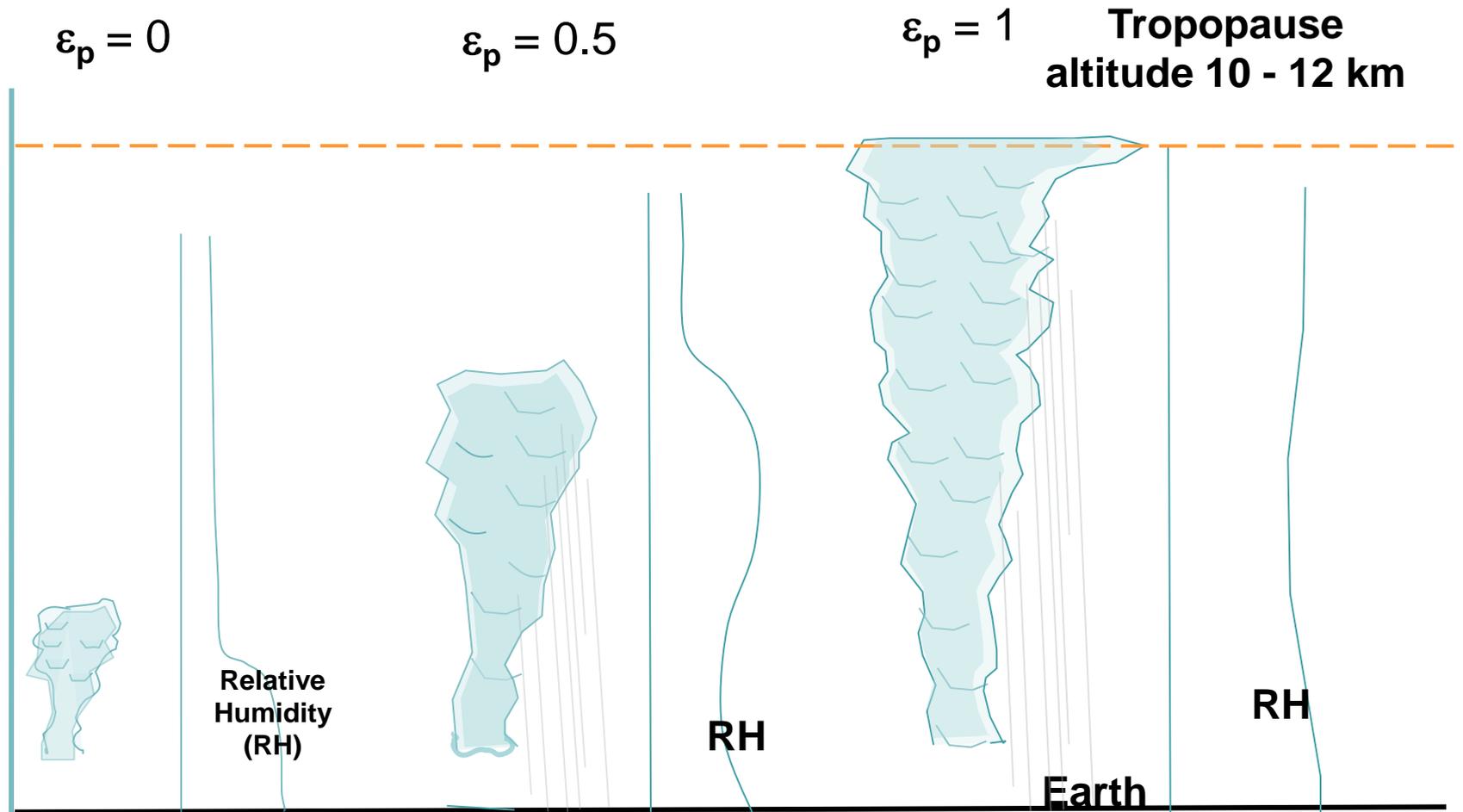
**Solarmission's projected full-scale solar updraft tower will produce an updraft of 300 tonnes of air per second containing around 3 tonnes/sec of water.**

**The glass solar canopy of a solar updraft tower is required to be in the region of five to seven kilometres in diameter.**

**One 200 MWe Solar Updraft Tower will dissipate around 20 Gigawatts in terms of atmospheric convection.**

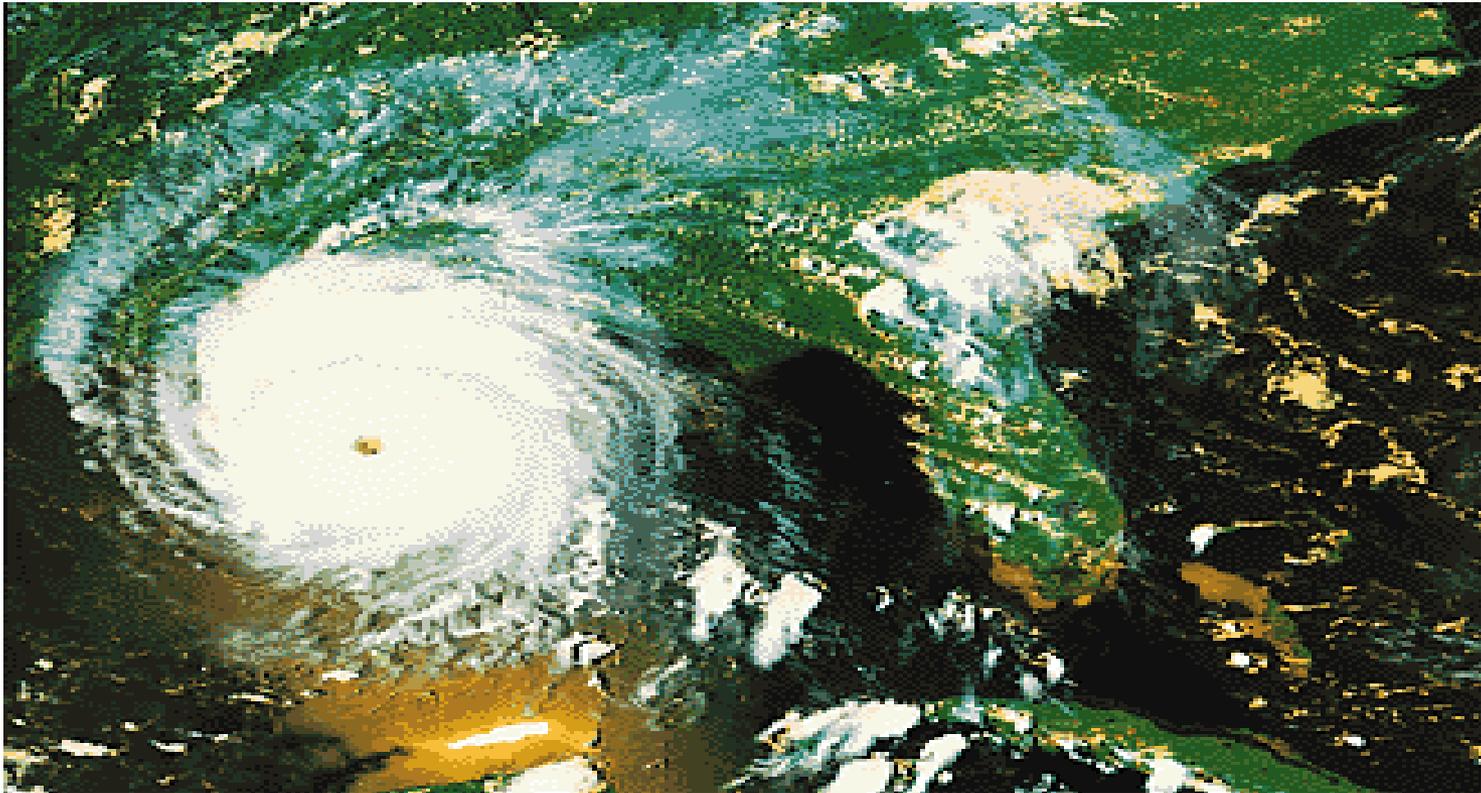
**A cloud will often be formed above the top of the updraft tower, but precipitation from the cloud is likely to be limited because of its relatively low altitude.**

# Precipitation Efficiency ( $\epsilon_p$ ) vs. Cloud Height



When clouds reach the top of the Troposphere, precipitation efficiency tends towards unity. Some evaporation occurs during the descent of the rain, but this is not an entire loss as the evaporation causes cooling of the surrounding air, subsequent downdrafts, and horizontal wind when the flow hits the ground. Some of this energy can be harvested by means of conventional wind turbines.

# Vortices in Nature



NASA

**The Tropical Cyclone**

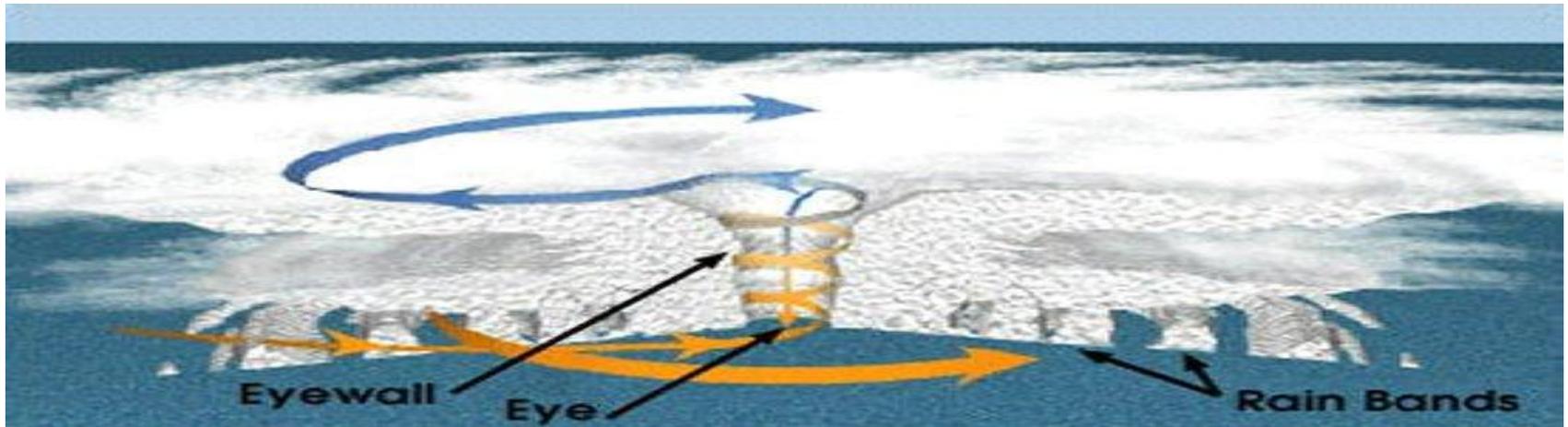
# Vortices in Nature



A severe tropical cyclone can dissipate in the region of 30,000 Gigawatts. Australia's electrical power generation capacity is in the order of 50 Gigawatts.

# Vortices in Nature

(Not to scale – the eye is typically 40 km in diameter and 12 km high)



Wikipedia

The driver for the tropical cyclone is normally the enthalpy of water vapour within humid tropical air.

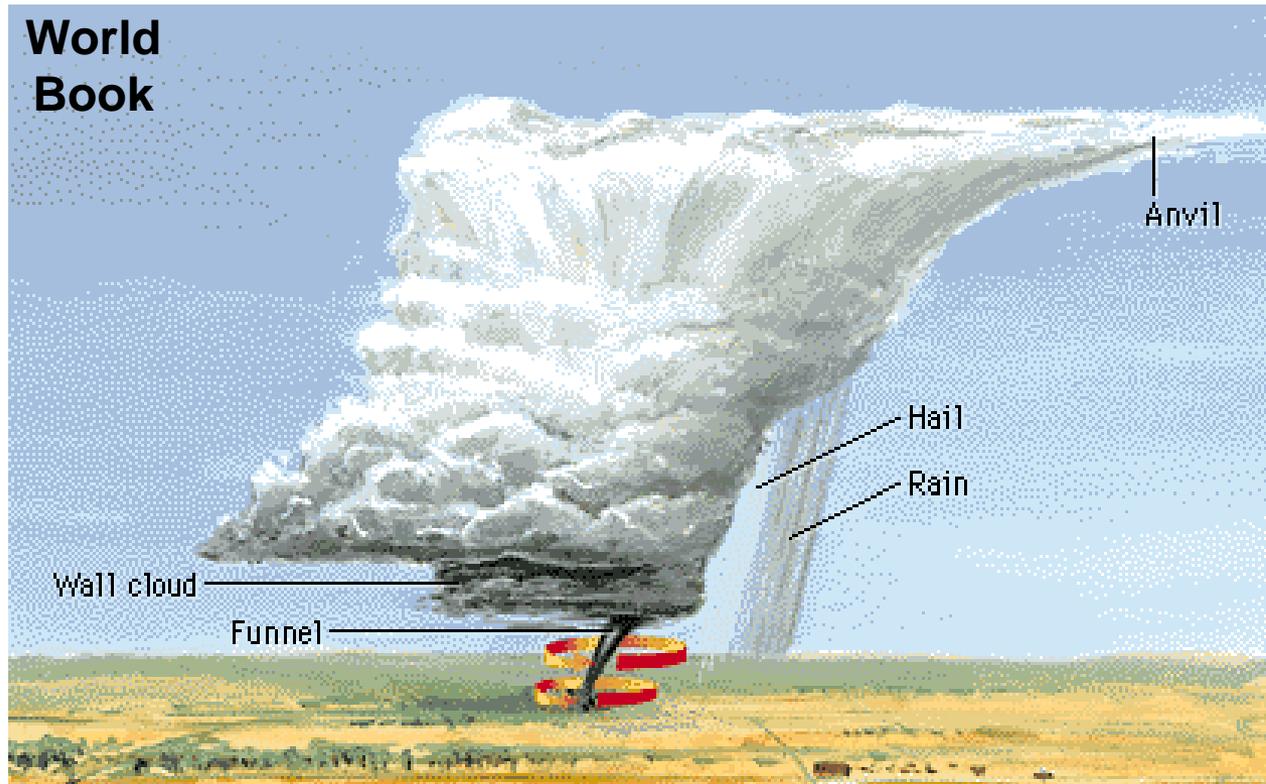
# Vortices in Nature



Wikipedia

**The Tornado**

# Vortices in Nature



**The Tornado: - a highly effective mechanism by which Nature conveys the moist boundary layer air to the top of the Troposphere where precipitation is initiated. The “anvil” is formed when it reaches the Tropopause, the interface with the Stratosphere.**

# Vortices in Nature



NASA

**The Tornado**

# Nature's "Heat Pump"

*Convection processes such as storms, cyclones and tornados are the primary means of effectively pumping heat out of the ocean, into the atmosphere, and lifting it to where it can be radiated into space, thereby mitigating the heat build-up that otherwise occurs.*

# The Atmospheric Temperature Profile

**It has been shown by MIT Professor Kerry Emanuel that tropical cyclones are based on a close approximation of the Carnot cycle.**

**Within the Troposphere, the temperature varies from approximately 30°C (~300 K) at ground level to minus 70°C (~200 K) at an altitude of 10 kilometres. The Carnot thermodynamic cycle working between these limits has a theoretical efficiency of up to 33%.**

**The frequency of these events is arguably only the “tip of the iceberg.” There is always a potential for vortex generation, particularly strong in hot and humid regions**

# The Carnot Engine

The ideal thermodynamic efficiency of a Carnot cycle is a function of difference between the extreme temperatures of the cycle. The relationship between efficiency and temperature difference is given by

$$\begin{aligned}\eta &= \frac{\text{Max.abs.temp} - \text{Min.abs.temp}}{\text{Max.abs.temp}} \\ &= \frac{T_2 - T_1}{T_2}\end{aligned}$$

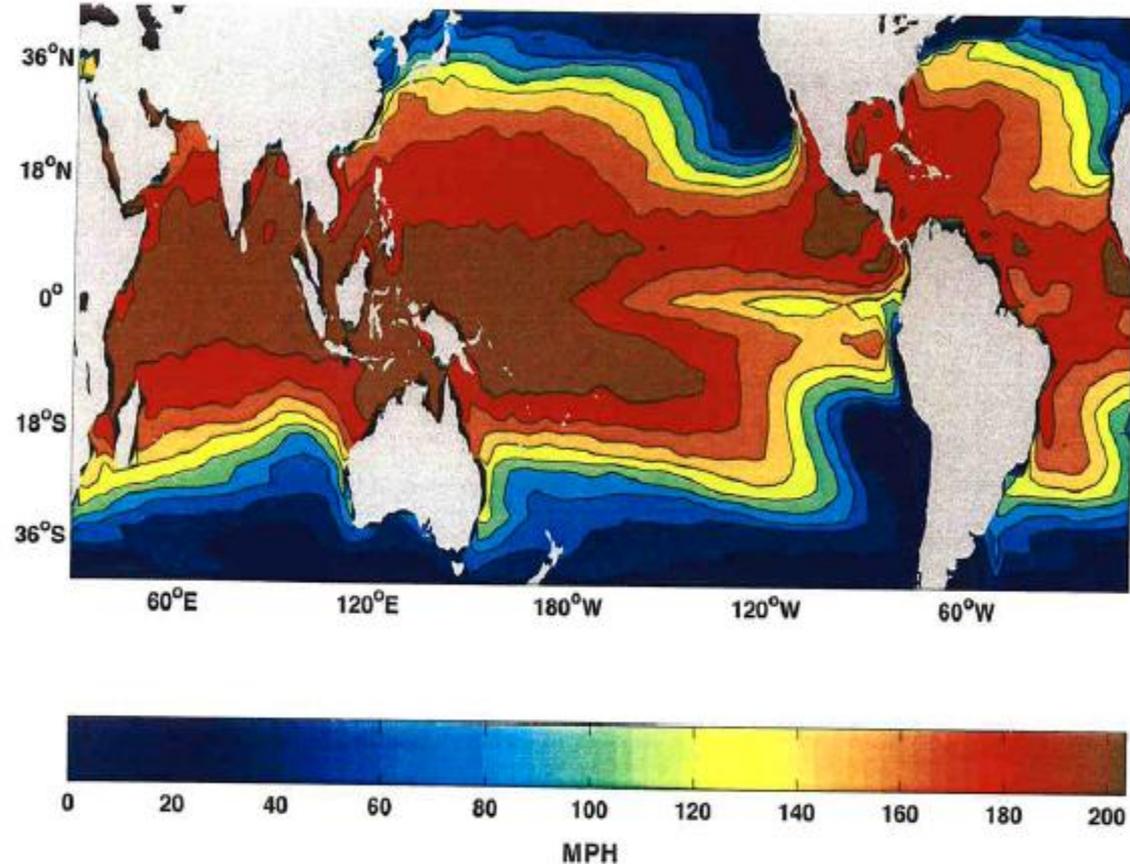
*Hence for the temperatures involved in this case*

$$\begin{aligned}\eta &= \frac{300 - 200}{300} \\ &= \frac{100}{300} \\ &= 33\%\end{aligned}$$

# The Carnot Potential Wind Speed

Map showing the maximum wind speed in MPH achievable by tropical cyclones over the course of an average year according to Carnot's theory of heat engines.

Source: *Divine Wind* by Kerry Emanuel



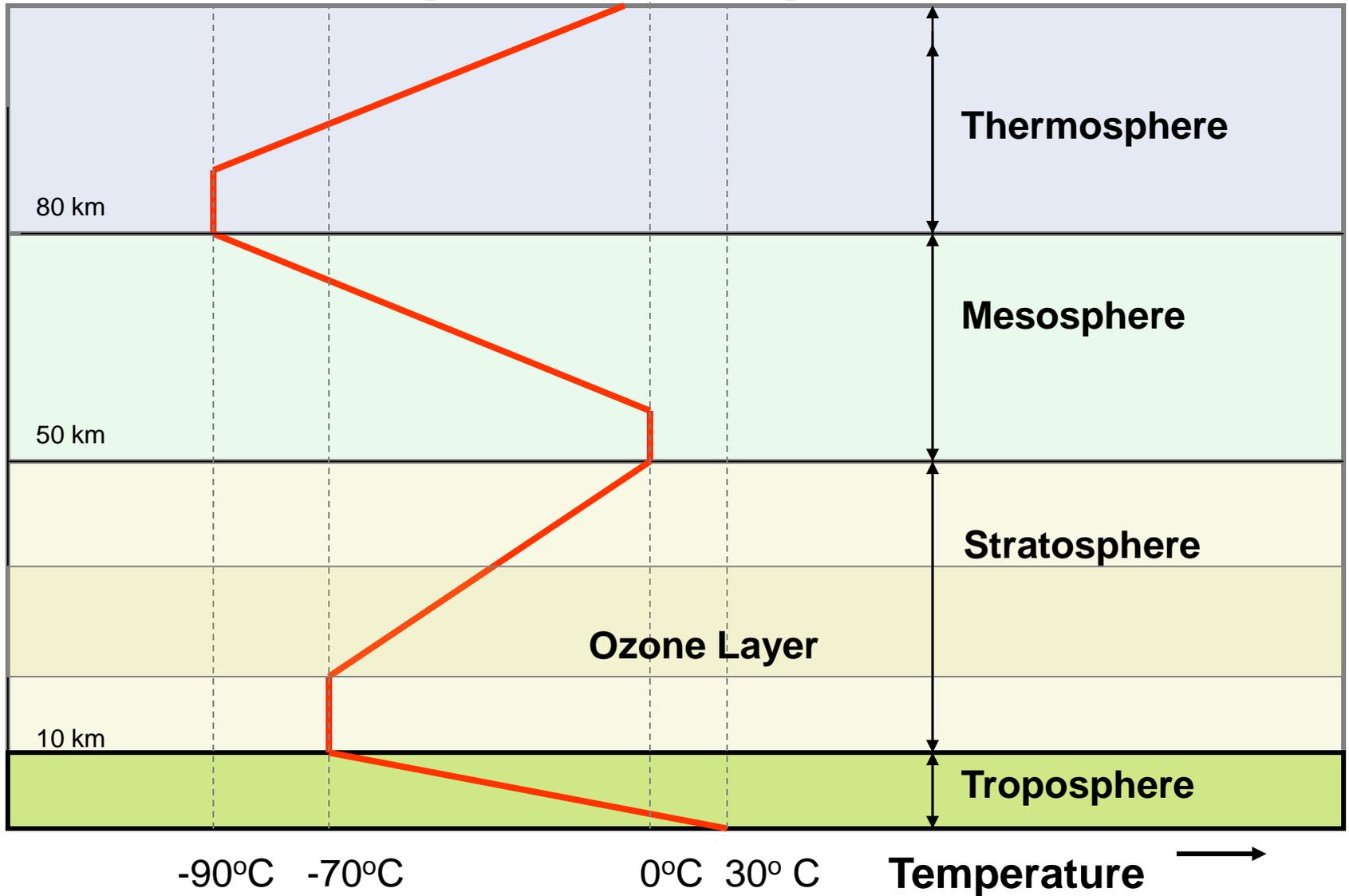
**Cyclonic energy is normally derived from the moist air over a warm sea**

# Australia's Position

**From the Carnot potential wind speed distribution, it can be seen that Australia is positioned in a region of high cyclonic potential.**

**This has usually been seen as a problem, but there is a strong argument that it may be turned to an advantage.**

# The Atmospheric Temperature Profile

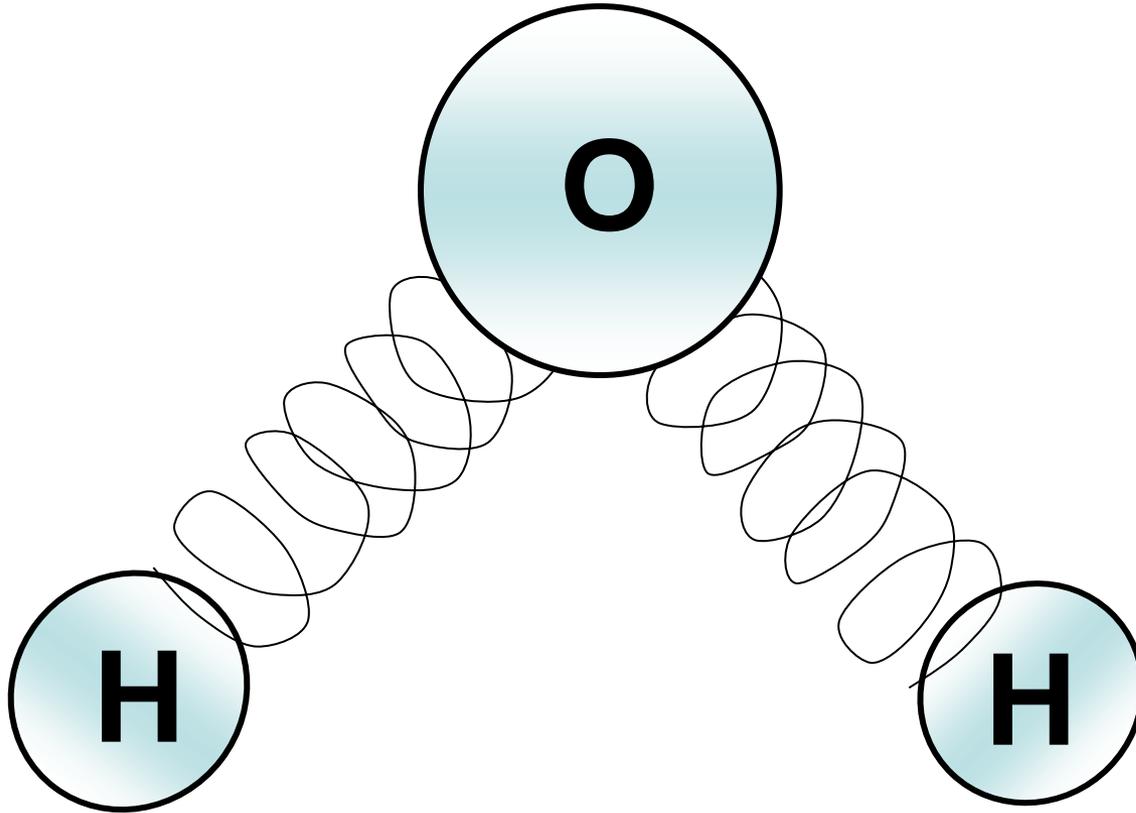


# **The Atmospheric Temperature Profile:**

**Generally atmospheric temperature declines with altitude except where:**

- incoming solar radiation is absorbed in the Stratosphere (in which the Ozone layer lies), and**
- “solar wind” particles are intercepted in the Thermosphere which includes the Ionosphere.**

# The Vapor Field as Solar Collector



**Tri-atomic molecules such as carbon dioxide and water vapor are efficient absorbers of infra-red radiation**

**A vapor field can absorb energy by two mechanisms:**

**1. Radiation (absorption of infra-red radiation from within the environment)**

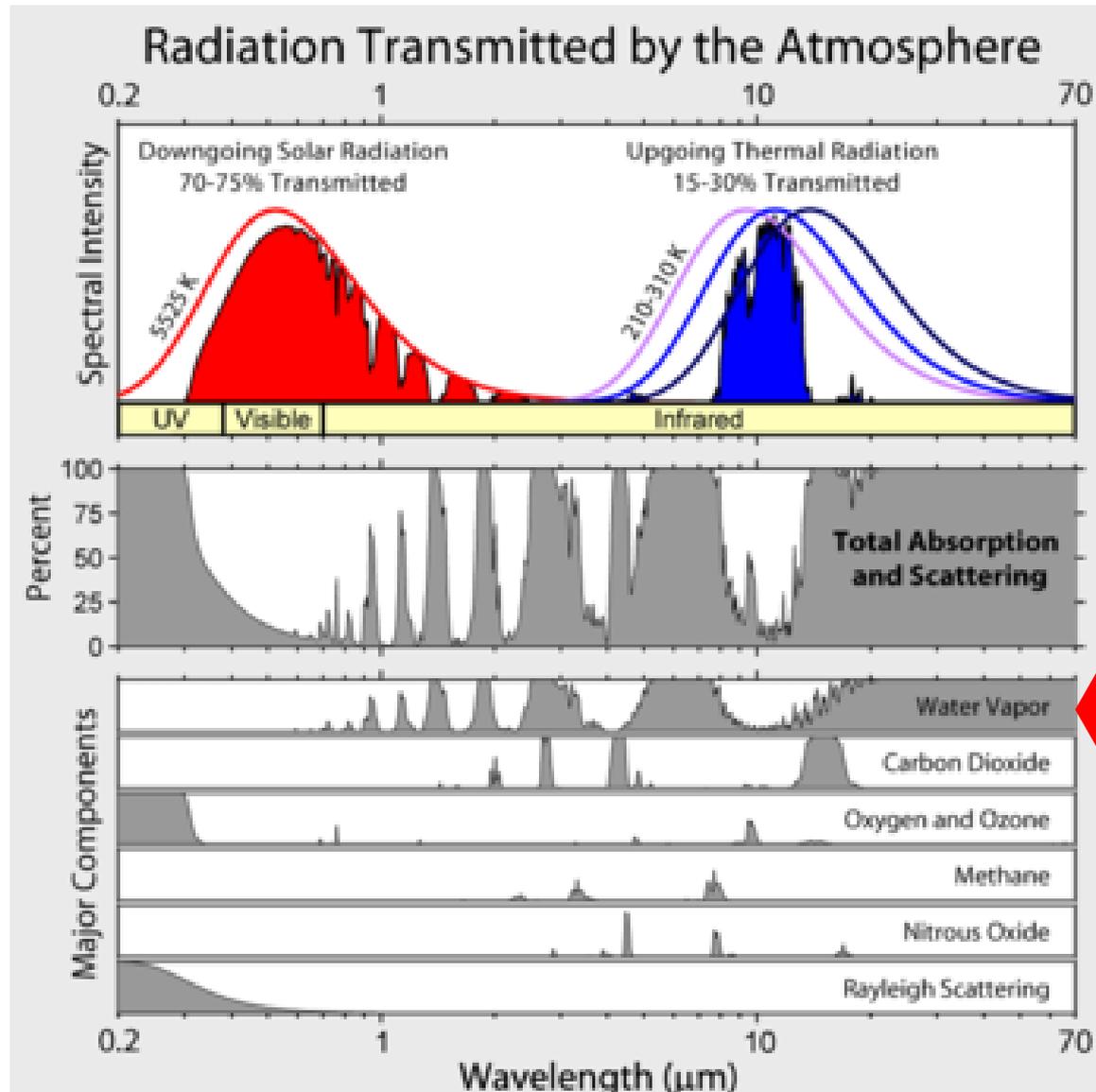
**2. Conduction (from the surrounding hot air)**

# Absorption of Infra-Red Radiation

“...compared to molecular nitrogen and oxygen, water vapor molecules are capable of great gymnastic feats. Besides being able to stretch and compress, they can bend at their mid-sections, rotate, and perform combinations of stretching, bending and rotating. Because they can move in such complex ways, they can absorb and emit much more radiation than molecules that consist of only two atoms... Changes in energy state of a single molecule are communicated to neighboring molecules with which it collides... Absorption of radiation... increases air temperature...”

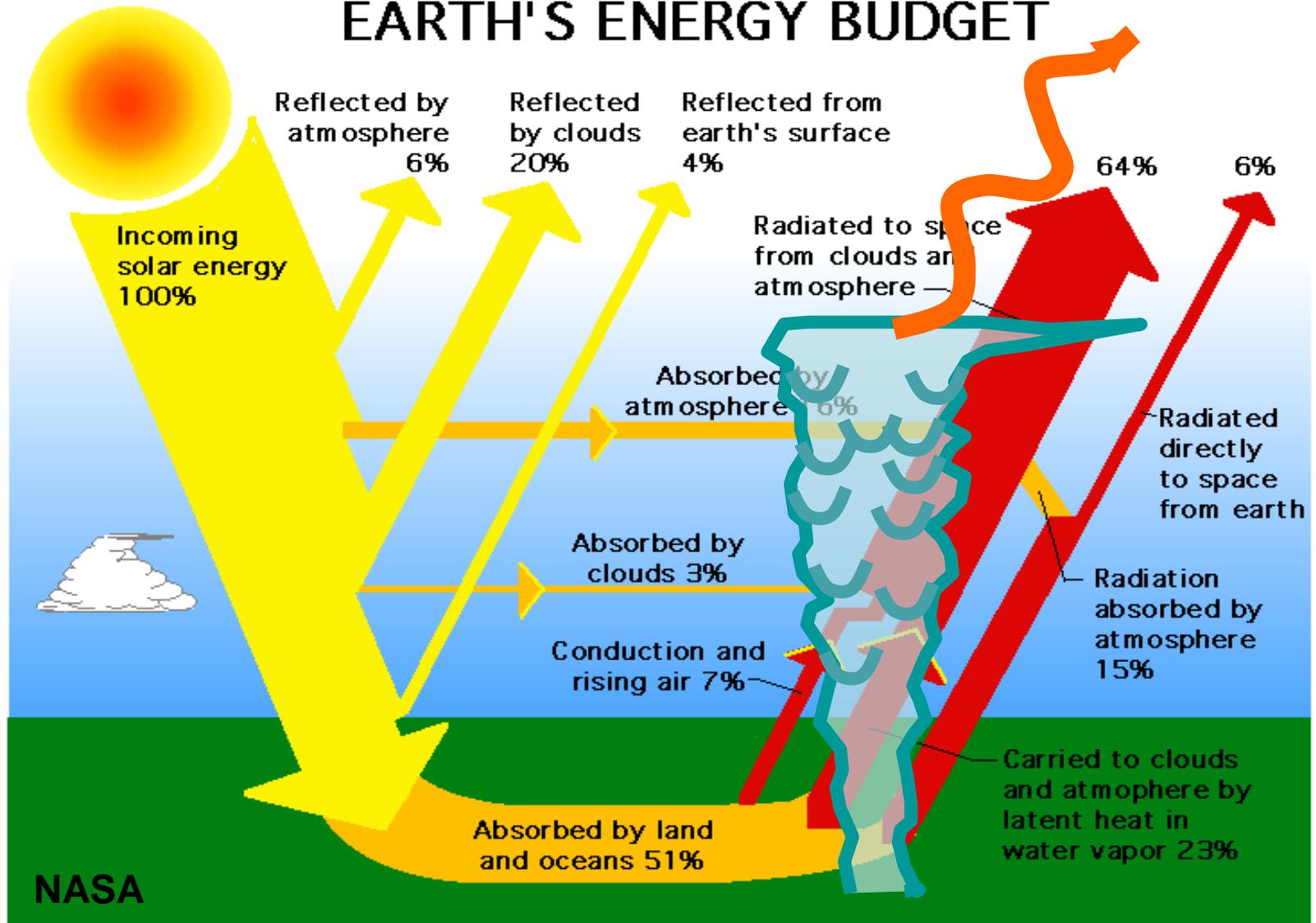
Professor Kerry Emanuel MIT

# The Greenhouse Effect



**Water vapor is by far the most important greenhouse gas**

# EARTH'S ENERGY BUDGET



Convection of water vapor through the Troposphere provides the most effective way in which heat can be eventually re-radiated to Space.

**Water vapour is a villain of global warming but it can be the hero:**

**It is a villain because it absorbs solar energy (infra-red radiation) and hence contributes to the greenhouse effect**

**It can be the hero because it is an ideal medium for transportation of energy to the top of the Troposphere where heat can be radiated into space.**

**...and we can sustainably tap off a small but significant percentage of the energy on the way in order to drive our electrical generators...**

**The increasing number and severity of tropical cyclones and tornadoes is arguably a pointer to Earth's need to dump heat to Space.**

**That's fine, but we need to learn to control the location, frequency and intensity of the process...hence the need for Vortex Engine research**

# The Latent Heat of the Water Vapor is Released Within a Buoyant Plume

The energy required to transform a tonne (roughly one cubic metre) of ice at minus 70°C into vapor at 30°C is around 3.5 Gigajoules.

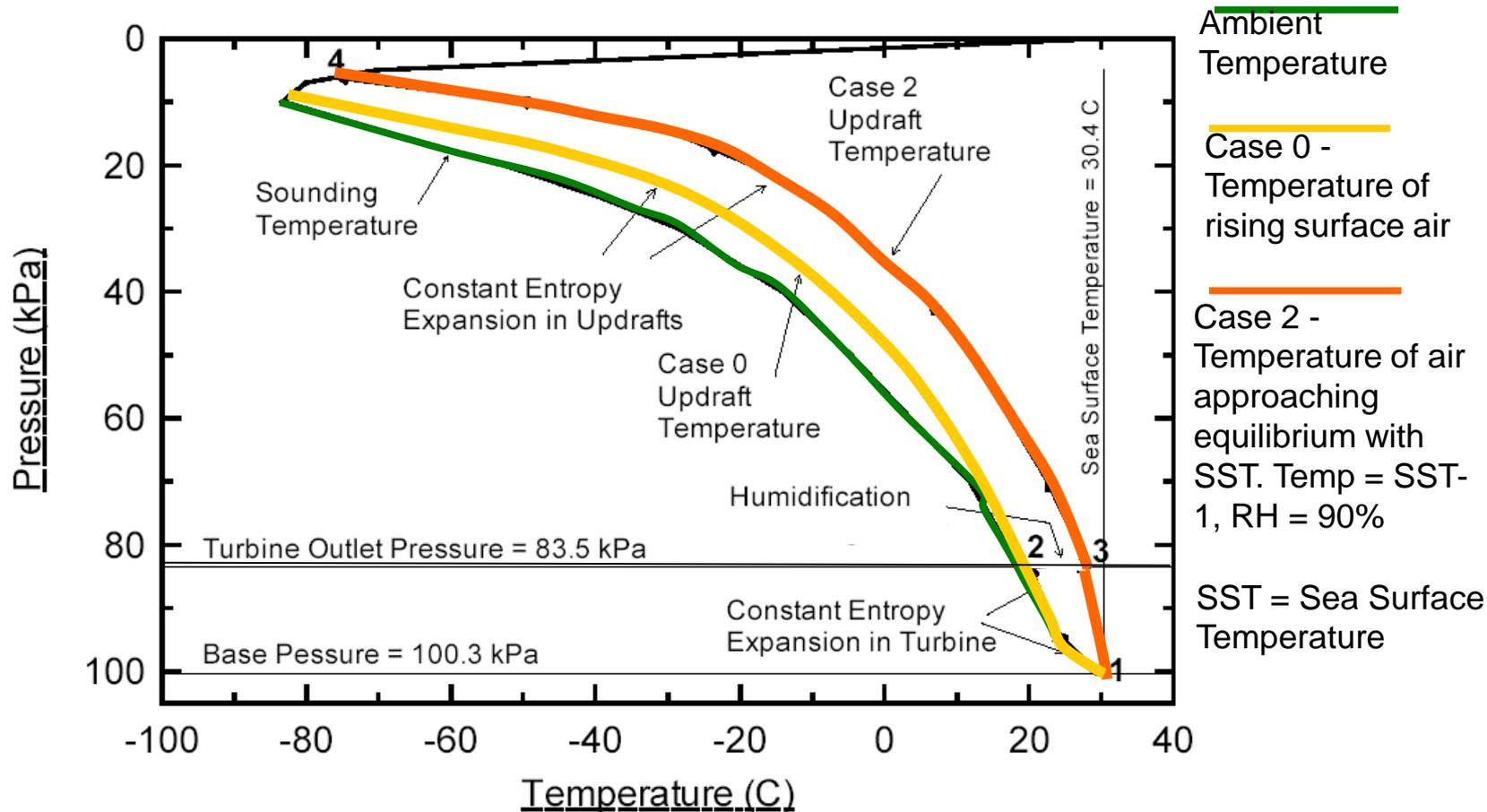
Conversely, transforming a tonne of water vapor into ice between the same temperature range *liberates* this amount of energy into the environment.

**This is comparable to the chemical energy contained in a hundred litres of fuel oil! The notional “volumetric ratio” of water to fuel oil is thus in the region of 10:1.**

In a rising plume, as the water vapor condenses and eventually freezes, energy is released, warms the surrounding air and this is manifested as an increase in the buoyancy and hence the corresponding potential energy of the air within the plume.

*This buoyancy can be utilized to convey the air-water vapor mixture to higher altitude, and in some instances supply excess energy for the production of electrical power as a by-product.*

# The Release of Latent Heat with Increase in Altitude



**The effect of humidification – the resulting higher temperatures increase the buoyancy of the plume**

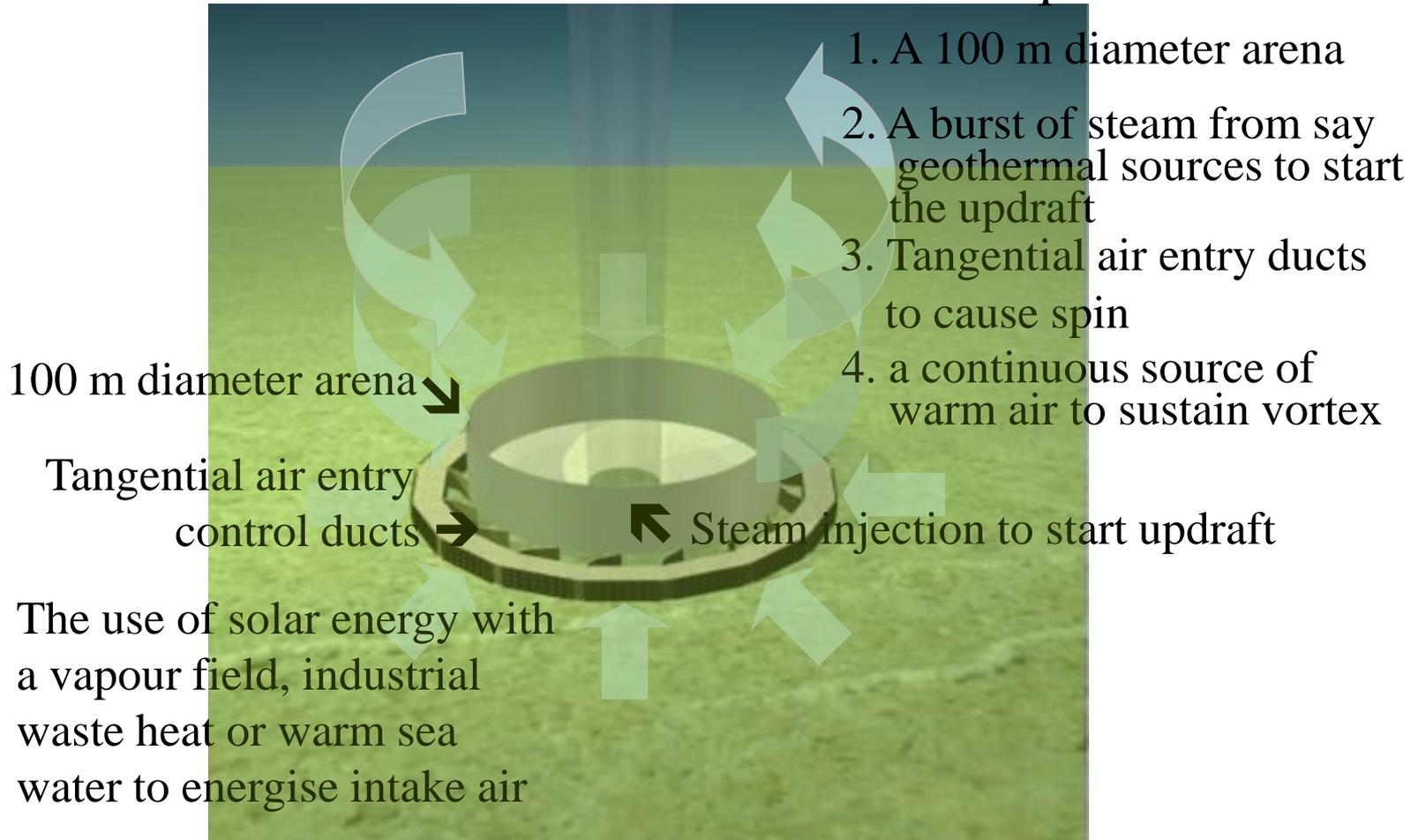
# The Energy Content of Atmospheric Water Vapor

It has been estimated that the Earth's atmosphere holds in the region of 12,900 cubic kilometres of water in the form of water vapor (ref: *The Case for Alternative Fresh Water Sources*; D Beysens & I Milimouk; *Secheresse*; Dec. 2000).

Based on the 10:1 rule of thumb, this then has the energy content equivalent to 1,290 cubic kilometres of fuel oil, and a significant percentage of this can be sustainably “harvested,” mostly for lifting water to an altitude where precipitation can be initiated, radiating heat to Space, **but also a small percentage for non-polluting renewable electrical power generation.**

The vortex principle, invented independently by Norman Louat in Australia and Louis Michaud in Canada is designed to achieve these aims.

All that is required is:



**An Atmospheric Vortex Engine would dispense with the solid stack and glass canopy of the Solar Updraft Tower.**

# Updraft Clouds

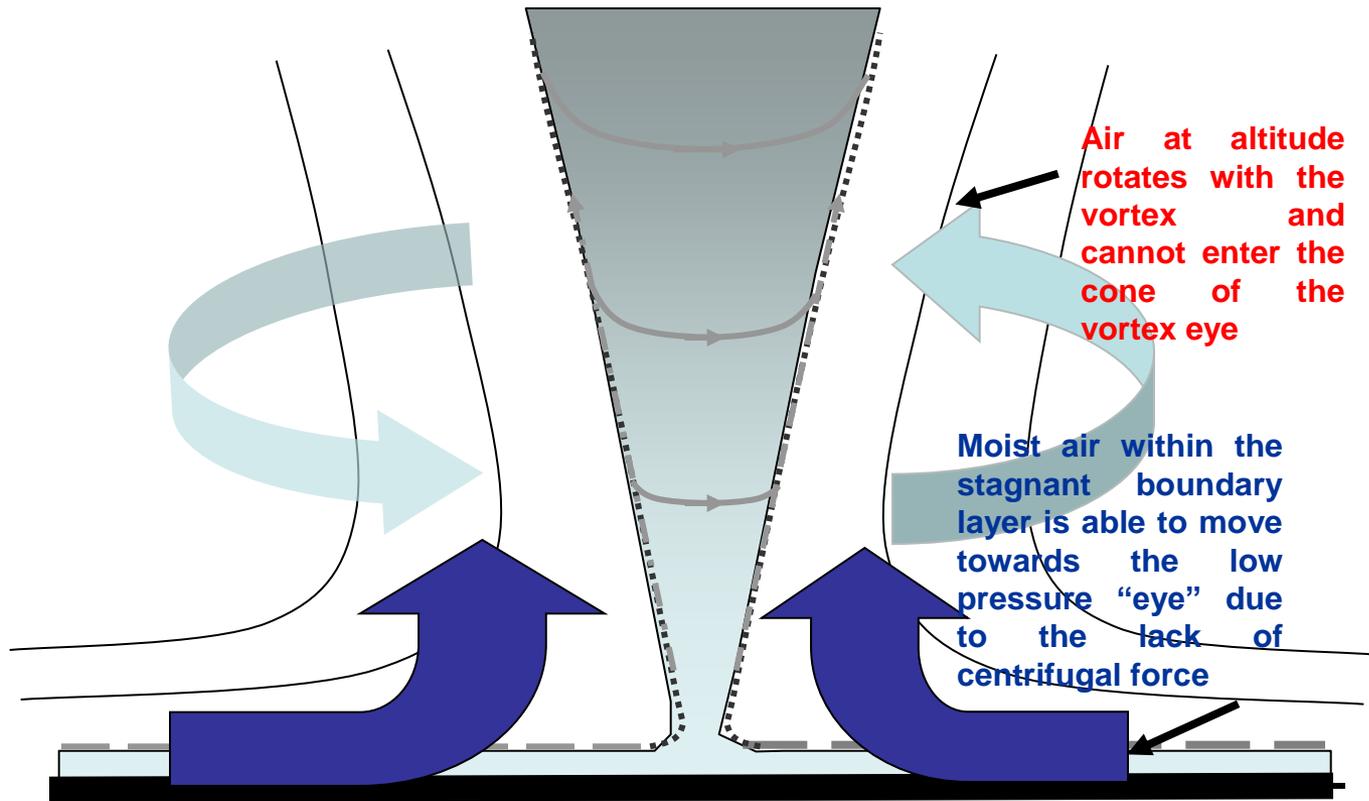


**Wikipedia/  
Bidgee**

**Updraft velocities of up to 240 km/hr have been recorded - Enough to hold hailstones of up to 178 mm diameter aloft.**

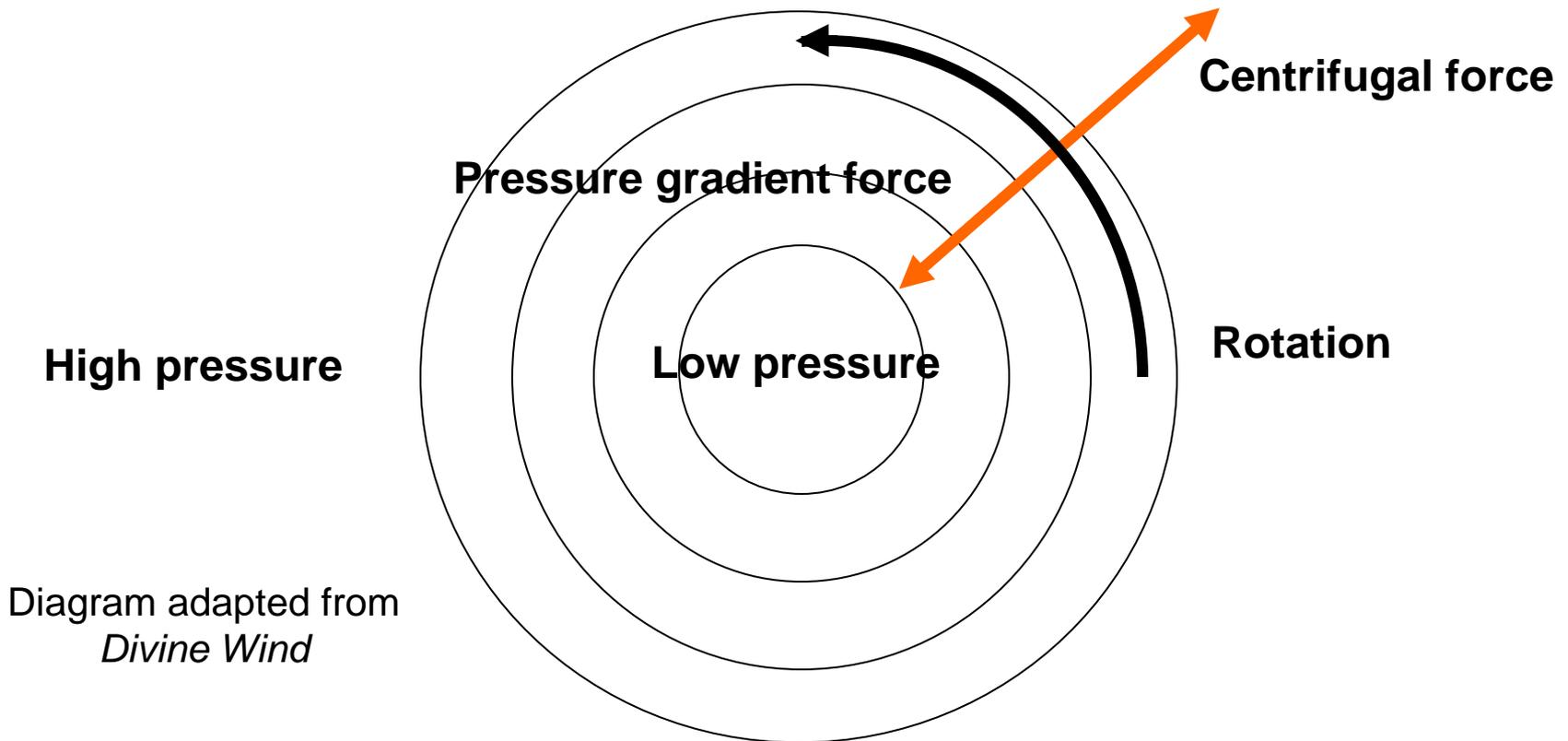
**Atmospheric water vapor should arguably be regarded as a storehouse of solar energy.**

# What makes the atmospheric vortex so powerful?



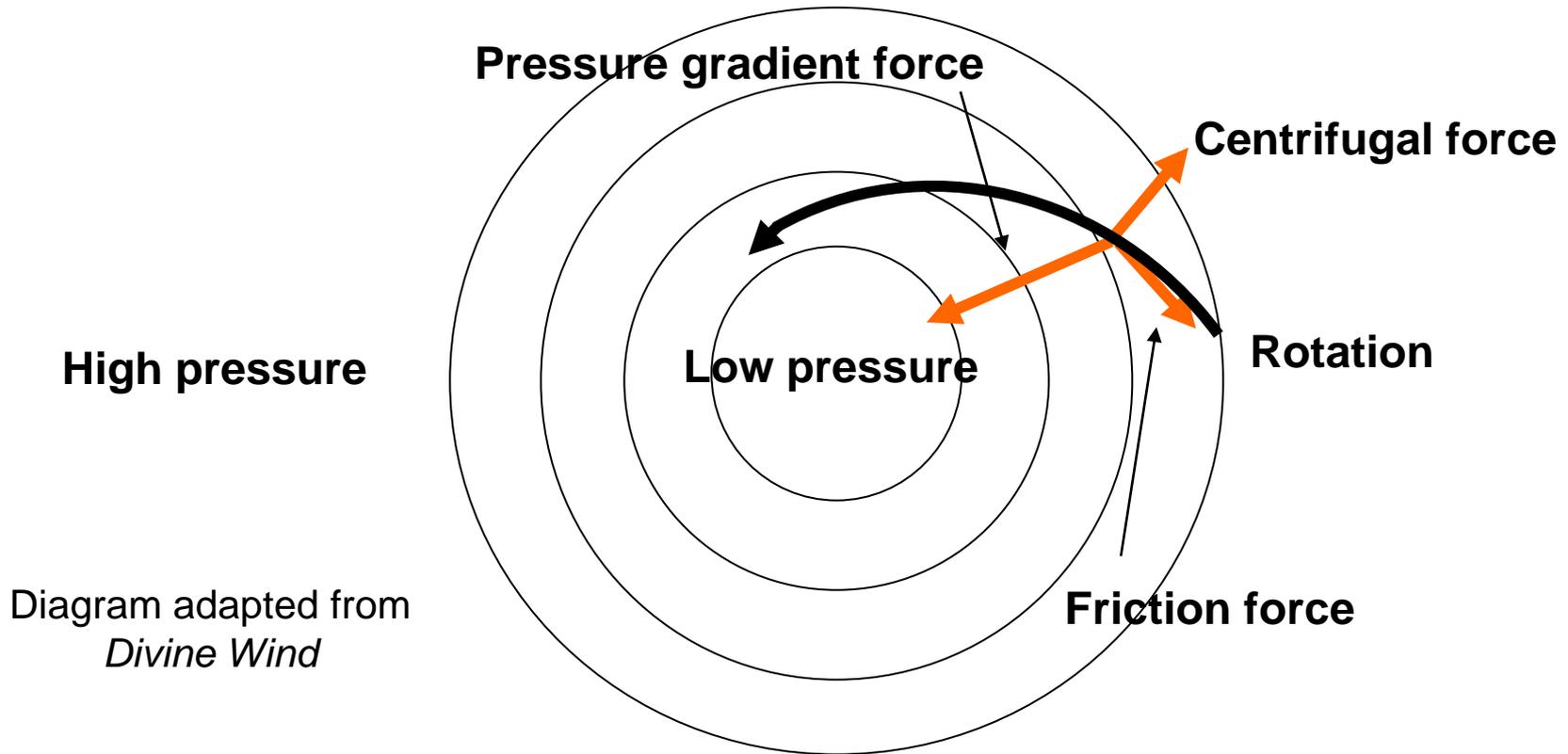
Diagrammatic representation of the dynamic vortex chimney in a Tornado:

# Airflow in a Vortex at Altitude



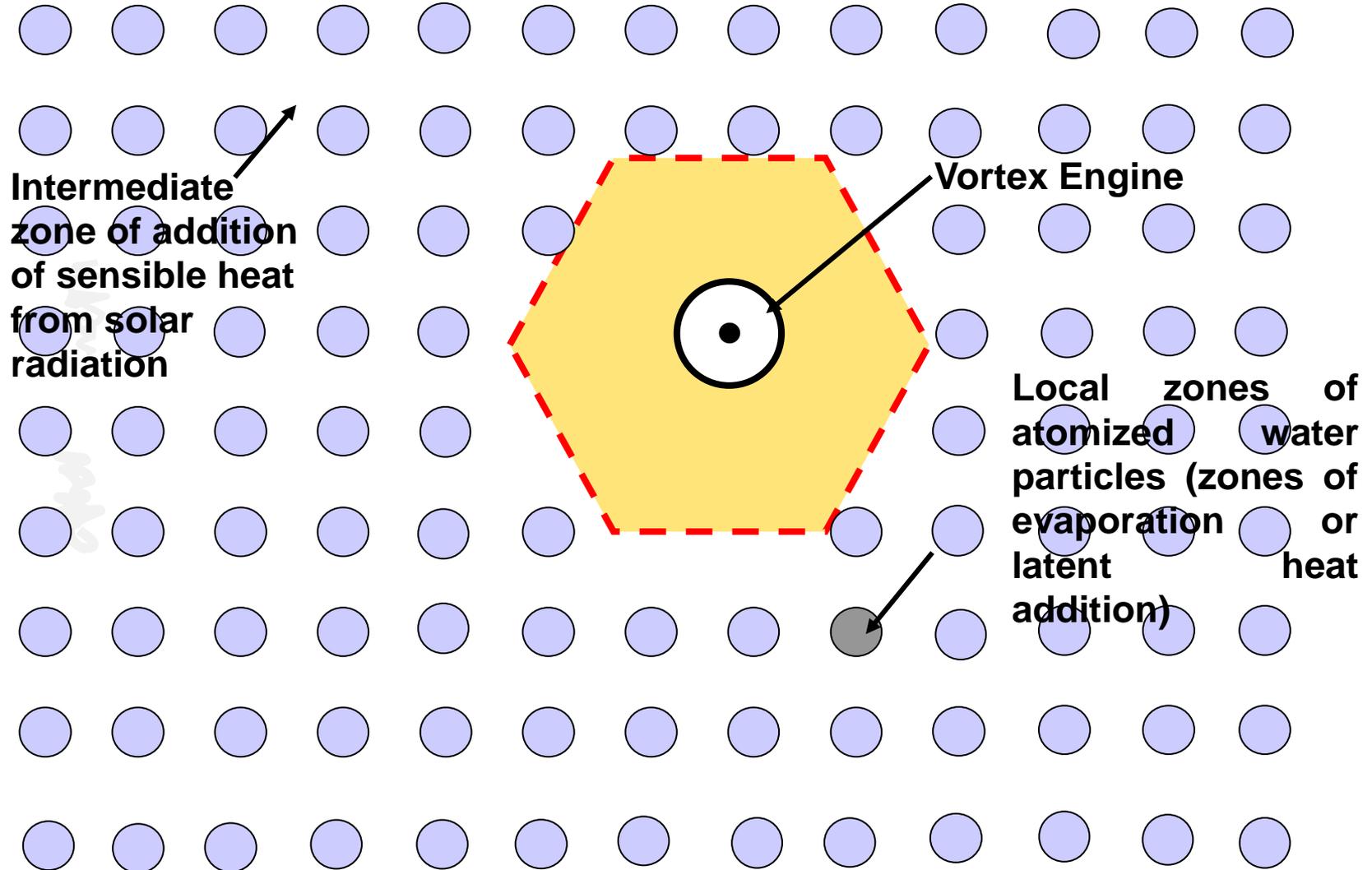
**At altitude, the pressure gradient force (inwards) exactly equals the centrifugal force (outwards). The air rotates without a significant radial component**

# Airflow in a Vortex at Ground Level



**Near the ground, friction acts to reduce the rotational velocity and hence the centrifugal force. The air spirals towards the centre.**

# The Utilisation of a Vapour Field to Facilitate Absorption of Solar Radiation



# The Possibility of Fighting Salinity

Absorption of infra-red radiation by the vapour field can create the high energy feedstock needed for the vortex engine – **recall that cyclones are born in a warm humid environment**

Pumping and atomizing groundwater can allow a vapour field to be created around the vortex engine

As the water spray begins to evaporate, the remaining droplets will become higher in salt concentration and hence density, and fall to earth. The ideal place to site the vapour field would be over the bed of a dry salt lake. The salt could be harvested as a by-product.

The surrounding environment within a radius of 30 – 40 km would have enhanced rainfall.

# Advantages of Convective Vortex Systems

- Zero CO<sub>2</sub> emissions
- Zero fossil fuel use – instead the use of stored solar energy within atmospheric water vapor and air
- Increased precipitation means increased photosynthesis – hence less CO<sub>2</sub>
- Increased precipitation means increased runoff into the Oceans – reduced atmospheric water vapor
- Increased heat radiation to space – global cooling
- Significantly increased terrestrial Albedo

**“...It all looks beautifully obvious – in the rear view mirror. But there are situations where one needs great imaginative power, combined with disrespect for the traditional current of thought, to discover the obvious...”**

**Arthur Koestler**

**Harnessing the vortex principle  
will not be easy, and the risks  
are considerable.**

**But research **must** be carried  
out to determine its viability**

# Disclaimer

As the author of this presentation I have to state that I am a total layman where meteorological processes are involved.

As a mechanical engineer my aim is to research the mechanics of generating a vortex and harness it to provide the potential environmental benefits.

Don Cooper