

---

Learning Material

# Eye of the Cyclone

Grades 8-10

---

Exercises

## Introduction

A typhoon named Maysak hit the Philippines on the 5th of February 2015. It was tracked by the cameras installed on the International Space Station (ISS). Material 1 deals with the structure and formation of tropical cyclones. Material 2 and 3 include a schematic drawing of a typhoon, and a weather map. The app “Eye of the Cyclone” shows i.a. the typhoon as recorded by the ISS cameras. Scan the QR-Code to download the app. You can find it on Google Play Store at

**[https://play.google.com/store/apps/details?id=eye\\_of\\_cyclone.VideoPlayback&hl=en](https://play.google.com/store/apps/details?id=eye_of_cyclone.VideoPlayback&hl=en)**.



Run the app and move your phone’s camera over both figures in material 3 and see what happens. You can answer the questions at the very end of this work sheet.

## Weather map

The white lines on the weather map in material 3, so-called isobars (lines connecting points of equal atmospheric pressure), depict air pressure on the earth’s surface; their average is 1013 hectopascal (hPa). Apart from the surface air pressure delineated in white, lines connecting points of equal atmospheric pressure are mapped as black isolines, isohypses. Isohypes state the heights above sea level (SL) with a specific atmospheric pressure – in this case 500 hPa - in decametre (1 dam = 10 m). This measure of height is easy to convert to metres by multiplying it by 10. Some weather charts include the air temperature (usually coloured) in a specific height, e.g. 500 hPa. In this figure, the temperature is not represented in colour, but rather as a so-called “relative topography” of the pressure on the earth’s surface and in a specific height. Units are decametres here, too. The relative topography states the thickness of the air layer within the pressure level. As warm air expands more than cold air, warm air layers are greater than cold ones. Basically, the colourful depiction can be compared to the depiction of mountains and valleys on a topographical map.

## Tasks

**You can answer the questions on the squared paper at the very end of this work sheet.**

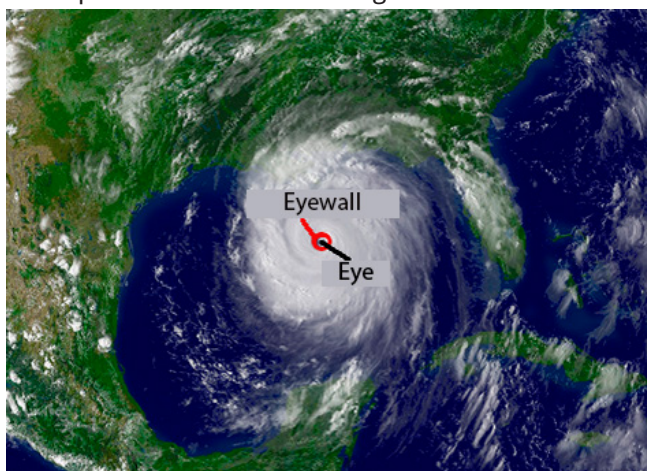
1. What is Typhoon Maysak’s rotational direction? What force is responsible for the cyclone’s rotation? See figure 1 in material 3 with the app.
2. Why is the air in the eye of a cyclone warmer than outside?
3. What’s the name of the scale, the intensity of a cyclone is measured with?
4. What conditions are necessary for a cyclone to form (mention at least 2)?
5. In the sample solution the weather map of March 27th, 2015, 12 o’clock UTC (Coordinated Universal Time) is displayed.
  - a) Draw the rough track of the cyclone, with the help of material 3 together with the app.
  - b) Calculate the cyclone’s traveled track in kilometers, considering the given scale.
  - c) Calculate its average speed.

## Material 1: Why Is the Eye of a Hurricane Calm?, by Natalie Wolchover, Live Science

Rather than being a poor pocket of peacefulness trapped by turbulence, terror and torrential rains, the eye of a hurricane is actually more like the evil mastermind of the whole operation.

The formation of an eye — that circular, blue-sky patch in the center of a vortex that is typically 20 to 40 miles (30-65 km) across — almost always indicates that a tropical storm is becoming more organized and stronger. For this reason, meteorologists watch developing storms closely for signs of one. But why do they form?

Like so many complex weather systems, scientists don't fully understand the process. By one count [pdf], hundreds of theories have been put forth as to the exact mechanism of their formation. But they all attempt to flesh out the same general idea:



**Figure 1: Eyewall and Eye of Hurricane Katrina (August 25th, 2005). Quelle: NOAA.**

In a tropical storm, convection causes bands of vapor-filled air to start rotating around a common center. Suddenly, a band of air at a certain radial distance starts rotating more strongly than the others; this becomes the „eyewall“ — the region of strongest winds that surrounds the eye in a hurricane. The rotating winds cause updrafts: air that moves from the ocean's surface to the top of the storm. Most of this air then flows out over the storm clouds and down around the outer edge, back to where it started. This sets up a positive feedback loop, which drives the storm's development.

For reasons unknown, not all the air that rises from updrafts flows over the outer edge of the storm; a small amount goes the other way, sinking down through the storm's center. At a certain point, the weight of this rogue air counteracts the strength of the updrafts in the central region. Then it overtakes their strength, but just barely: Air begins to slowly descend in the center of the storm, creating a rain-free area. This is a newly formed eye.

On land, the center of the eye is, by far, the calmest part of the storm, with skies mostly clear of clouds, wind and rain. Over the ocean, however, it's possibly the most dangerous: inside, waves from all directions slam into each other, creating monster waves as tall as 130 feet (40 meters).



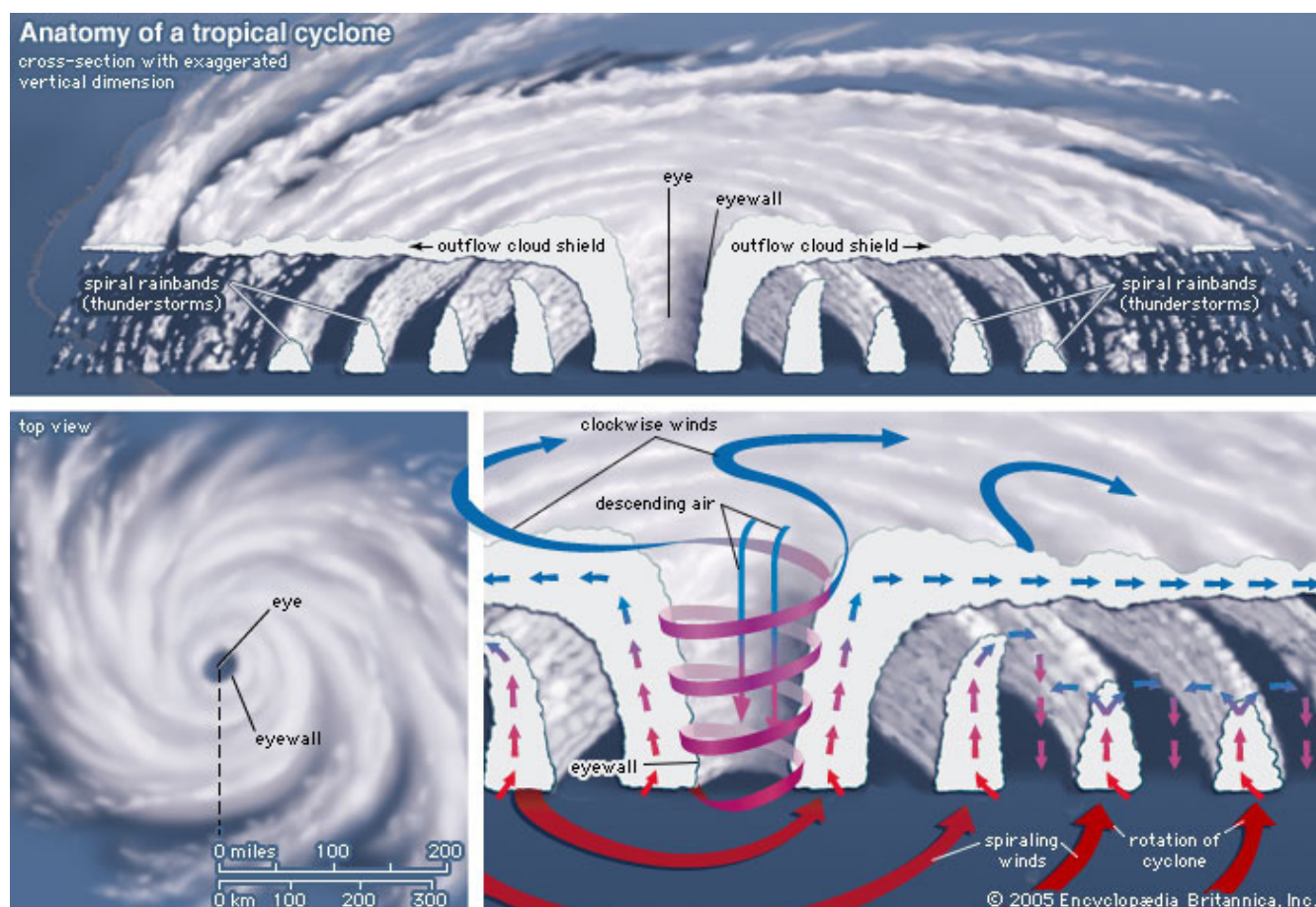
**Figure 2: In the Eye of Hurricane Katrina (2005). Source: NOAA.**

Though the passing calmness might lure you out of your home or shelter, the National Weather Service strongly recommends that you stay indoors. People are often caught off guard by violent winds from the opposite side of the eyewall.

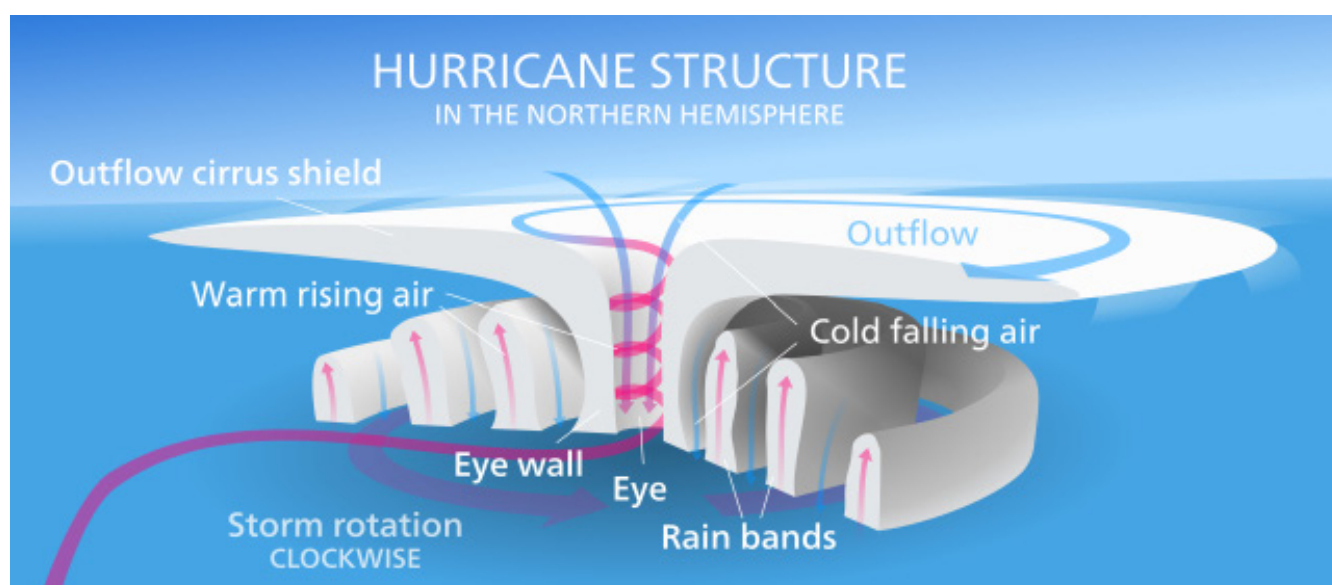
No one fully understands it, but as far as hurricanes are concerned, it goes like this: First an eye, then the world.

© Live Science, <http://www.livescience.com/15805-calm-hurricane-eye.html>

## Material 2a: Anatomy of a tropical cyclone



## Material 2b: Hurricane Structure



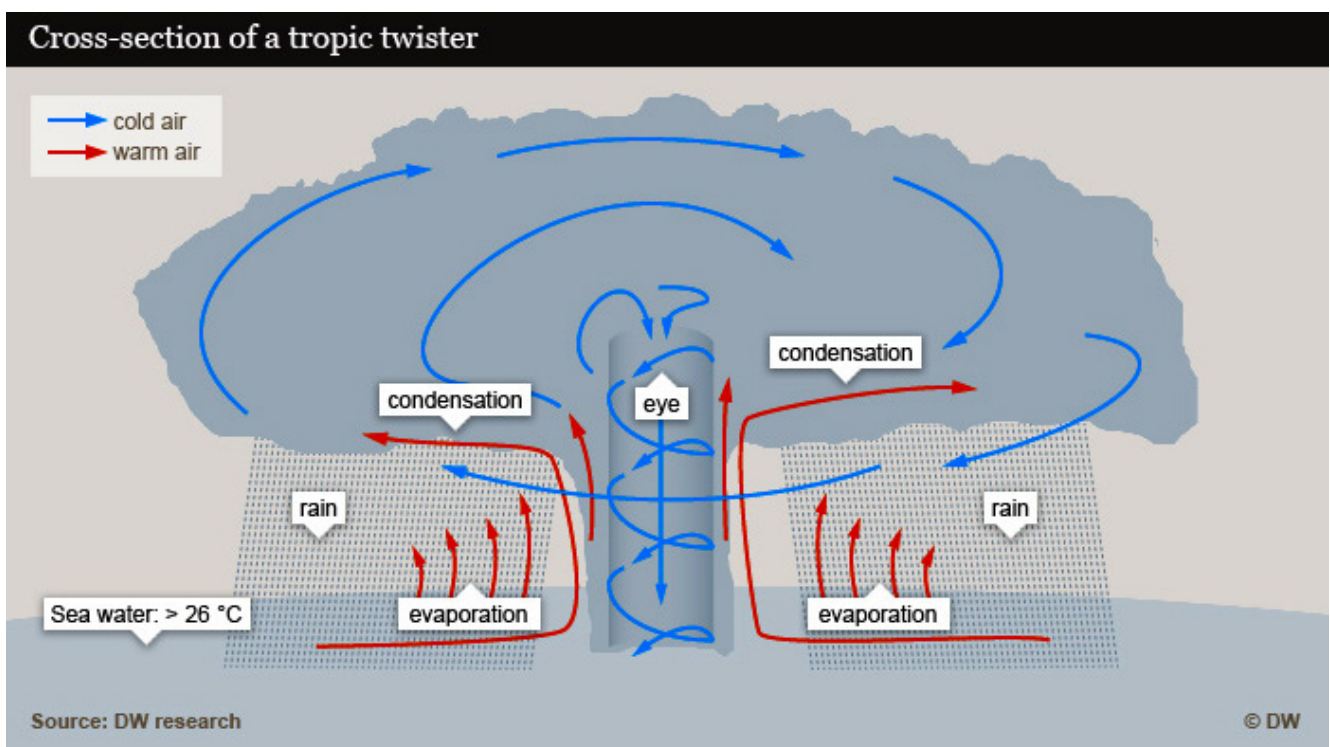
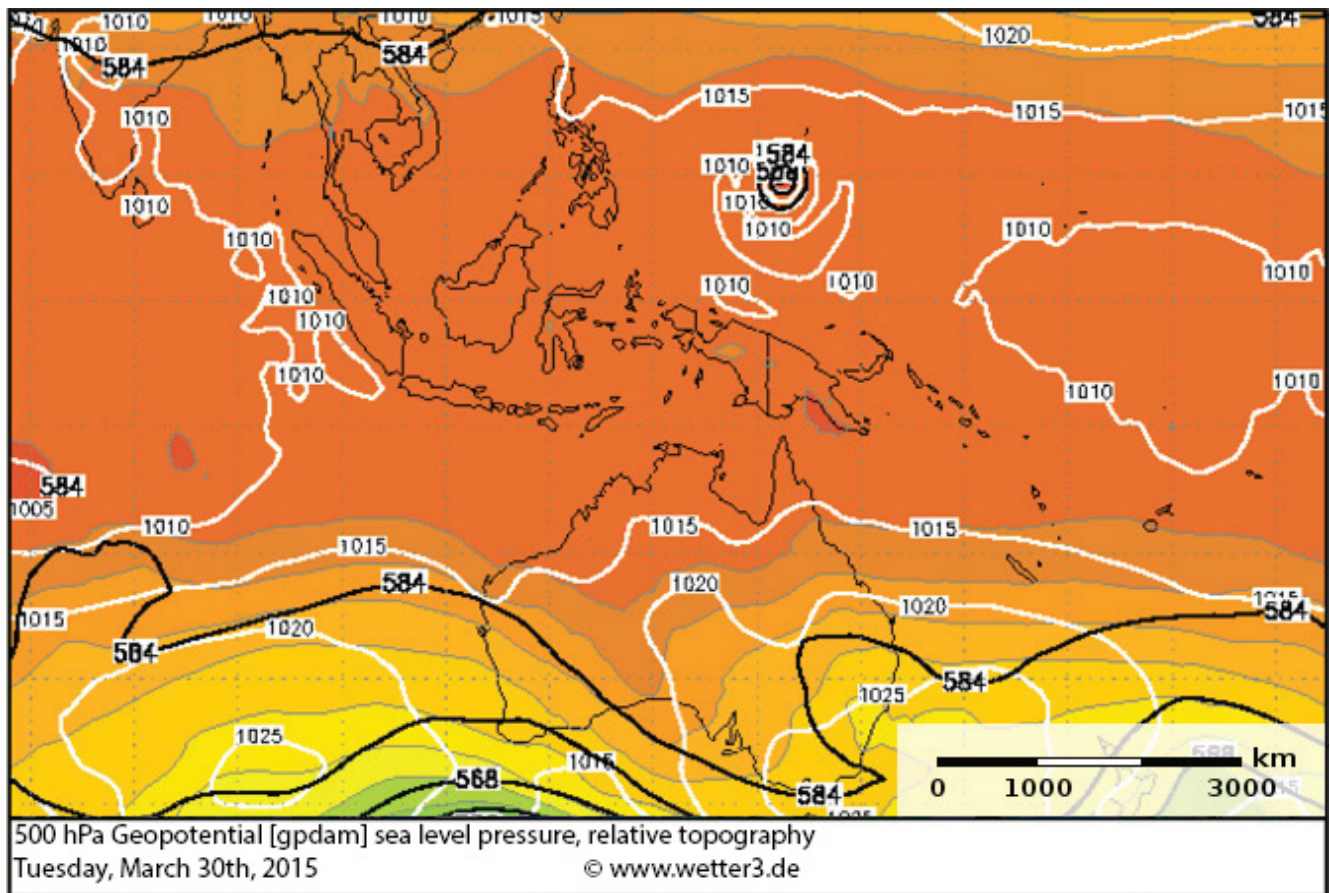
Licence: Creative Commons CC BY 3.0

Source: Wikimedia

Author: Kelvinsong



## Material 3: weather map and schematic picture of a typhoon



## Material 4: Hurricanes, Typhoons and Cyclones: Storms of Many Names, by Kim Ann Zimmermann, Live Science

There is an old expression that a hurricane is Mother Nature's way of telling us that she is angry. But of course hurricanes are not just a byproduct of nature's ire.

Hurricanes — or more broadly, tropical cyclones — generally begin as clusters of thunderstorms over tropical ocean waters, taking anywhere from several hours to several days to become organized and graduate to hurricane status.

There has to be a perfect storm, so to speak, of conditions for a hurricane to form, including:

- Water that is at least 80 degrees Fahrenheit (26.6 Celsius)
- Relatively moist air
- Very warm surface temperatures
- A continuous evaporation and condensation cycle
- Wind patterns of varying directions that collide (converging winds)
- A difference in air pressure between the surface and high altitude

Tropical cyclones form all around the world, generally about 300 miles (480 kilometers) north or south of the equator. When they form in the Atlantic or Eastern Pacific, the storms are called hurricanes. They are called typhoons in the western North Pacific and cyclones in the South Pacific and Indian Ocean.

The Atlantic hurricane season is from June through November, when the storms take shape on the coast of Africa. The Eastern Pacific season runs from mid-May through November. Typhoons occur year-round but peak in late August. In the South Pacific, the cyclone season begins in October and ends in May.

In the Atlantic region, hurricanes form anywhere from the tropical central Atlantic to the Gulf of Mexico. Hurricanes typically follow three paths:

- originating off the West Coast of Africa near the Cape Verde Islands and traveling west toward the Caribbean and the East Coast of the United States
- originating in the Western Caribbean, and moving into the Gulf Coast, or along the U.S. East Coast
- originating in the Gulf of Mexico and moving into the Gulf Coast states from Texas to Florida.

There are distinct levels of progression as a storm becomes a hurricane. The first stage is a tropical disturbance, which is essentially a significant cluster of showers and thunderstorms. As it becomes a tropical depression, it is slightly more organized and the winds pick up to 25 to 38 mph (40 to 61 km/h). It is classified as a tropical storm when winds reach 39 to 73 mph (62 to 117 km/h). Once the winds reach 74 mph, it is classified as a hurricane and its intensity is measured by the Saffir-Simpson Scale.

The Saffir-Simpson hurricane scale was developed in 1971 by civil engineer Herbert Saffir and meteorologist Bob Simpson, who at the time was director of the U.S. National Hurricane Center.

- Category 1: wind 74-95 mph (119-153 km/h)
- Category 2: winds 96-110 mph (154-177 km/h)
- Category 3: 111-129 mph (178-208 km/h)
- Category 4: 130-156 mph (209-251 km/h)
- Category 5: exceeding 157 mph (252 km/h)

Some storms are called super-typhoons when wind speeds reach 150 mph (241 km/h), according to the U.S. Joint Typhoon Warning Center. „Super-typhoons are much more intense than regular typhoons; they have a higher wind speed,” said Harold Brooks, a

research meteorologist at the National Oceanic and Atmospheric Administration (NOAA).

### Storm structure

The main parts of a hurricane are the rainbands, the eye and the eyewall. Air spirals in toward the center in a counter-clockwise pattern in the Northern Hemisphere (clockwise in the Southern Hemisphere) and out the top in the opposite direction. In the very center of the storm, air sinks, forming an „eye“ that is mostly cloud-free and extends 20 to 40 miles (32 to 64 km) in diameter.

The eye is surrounded by the eyewall, a ring of towering thunderstorms that inflict some of the storm's most severe punishment. Curved bands of clouds and thunderstorms trail away from the eye wall in a spiral fashion. These rainbands can produce heavy bursts of rain and wind, as well as tornadoes.

Tropical cyclones can get up to 300 miles (483 km) wide, but size is not necessarily an indication of inten-

sity. A hurricane's destructive winds and rains can extend outward more than 150 miles (242 km).

Winds are not the only hazard from tropical cyclones. Storm surges, when water is pushed toward the shore by the force of the winds, can increase the average water level 15 feet (4.5 meters) or more. Flooding also occurs, and in fact, causes most of the deaths during a tropical cyclone. More people are killed by floods than by any other weather-related cause.

### Naming the storms

Hurricane names are determined by the World Meteorological Organization in Geneva. The organization maintains six lists of alphabetical names that are used in rotation and recycled every six years. There are separate lists for Atlantic, Eastern North Pacific, Central North Pacific and other zones. Names are retired after a particularly deadly or costly storm. Most recently, the names Wilma (2005), Rita (2005) and Katrina (2005) were among the names removed from the lists.

**Blank Space for your Answers**

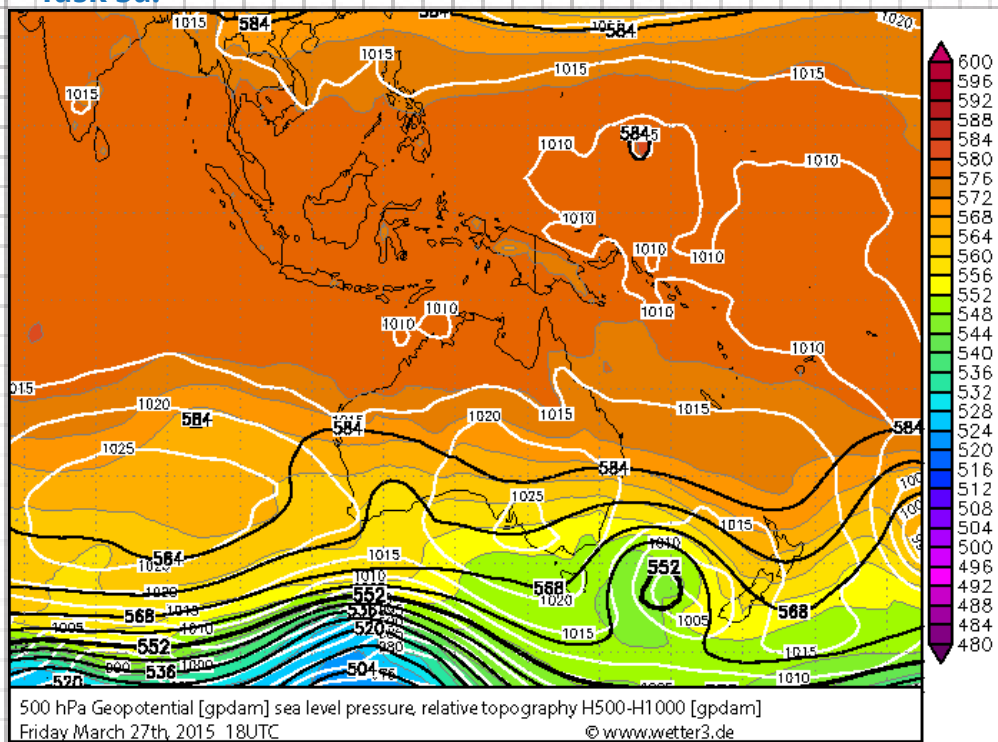
**Task 1:**

**Task 2:**

## Task 3:

## Task 4:

## Task 5a:



## Task 5b:

## Task 5c: