Pressure

Air is a touchable material, so it has a weight. Any object with weight, is influenced by a force, which is known as gravitational force. Atmospheric pressure is this force, per unit area, exerted against a surface, by the weight of air above that surface, at any given point in the earth's atmosphere. Low pressure areas have less atmospheric weight above their location, whereas high pressure areas have more atmospheric weight above their location. Similarly, as elevation increases there is less atmospheric weight, so pressure decreases with increasing elevation.

A column of air one square meter in cross-section, measured from sea level to the top of the atmosphere, will have a weight approximately 10.2 tons. Atmosphere pressure acts in all direction, basic unit of air pressure is N/m². The average atmospheric pressure at the earth surface is about 1013.2 hPa, with atmospheric pressure variation between about 940 hPa to 1050 hPa. (1 millibar = 1 hecto Pascal (hPa) = 10² N/m²)

**Mean sea level pressure (MSLP)** is the pressure at sea level. This is the amount of pressure reading, normally used on weather charts (by Navtax, Facsimile recorder etc) or weather reports (by VHF, radio, television, newspapers, Internet etc). When barometers are set to match the local weather reports, then they give pressure reduced to sea level, not the actual local pressure of that area.
**Why does all that air pressure not squash us?** Because we have air inside our body also, that air balances the outside atmospheric pressure.

**Atmospheric pressure measurement** is used to do previously, by U-tube manometer, one of the oldest methods to measure pressure, which is partially filled with a liquid, as described in below sketch. The pressure is measured on one arm of the U-tube, while the other arm is kept open to the atmosphere. The atmospheric pressure displaces the liquid, by pushing down through the open side and forcing the liquid level to rise on the other side. The difference in heights of the liquid levels is proportional to the pressure being measured. The pressure is the distance between the two liquid levels. Any convenient liquid can be used. But to make the U-tube smaller, heavy liquid is preferable. Accordingly mercury is the chosen, because the density of mercury is 13.6 times, more than water.

![U-tube manometer](image)

Then the barometer was developed in 1643, where previously water was used, as the liquid, which requires for this instrument. Afterwards people started to use mercury. Here a partially filled (by mercury) one end closed glass tube is inverted into a bowl, containing mercury (as below sketch). From the height of mercury, inside glass tube, can measure the pressure. A height of approximately 760 millimeters (29.92 in) of mercury, gives this readings of atmospheric pressure.

Some atmospheric pressure sensors are also used to measure atmospheric pressure, examples are below,

- **7010-A Microbarograph** – It is ultra sensitive, used in altitudes from 1,000 feet to 12,000 feet.
- **7020-A Hi-Q Barograph** – It continuously records atmospheric pressure, indoor or outdoor useable and also its span is adjustable for altitudes, between sea level to 12,000 feet.
- 7100 Precision Analog output Barometer – It is Ideal for remote locations.
- 7105-A Analog output Barometer – It is used from sea level to 14,000 feet elevation

**Pressure variation with height, place and time**

Air starts from the earth surface, then it slowly becomes thinner and fades into space at mesosphere. At height of around 120 km marks a boundary, where the atmospheric effects becomes unnoticeable, Since the amount of air is getting smaller with height, accordingly pressure will be lower. The following is a list of air pressures (as a fraction of one atmosphere) with the corresponding average altitudes. This table gives a rough idea of air pressures, at various altitudes.

<table>
<thead>
<tr>
<th>Fraction of one atmosphere</th>
<th>Average altitude (m)</th>
<th>Average altitude (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1/2</td>
<td>5,486</td>
<td>18,000</td>
</tr>
<tr>
<td>1/3</td>
<td>8,376</td>
<td>27,480</td>
</tr>
<tr>
<td>1/10</td>
<td>16,132</td>
<td>52,926</td>
</tr>
<tr>
<td>1/100</td>
<td>30,901</td>
<td>101,381</td>
</tr>
<tr>
<td>1/1000</td>
<td>48,467</td>
<td>159,013</td>
</tr>
<tr>
<td>1/10000</td>
<td>69,464</td>
<td>227,899</td>
</tr>
<tr>
<td>1/100000</td>
<td>86,282</td>
<td>283,076</td>
</tr>
</tbody>
</table>

Atmospheric pressure varies widely on earth and these changes are important in studying weather and climate. Due to earth-surface’s structure, height, type, position etc and sun’s declination, the re-radiation amount of sunlight varies with place to place and the earth surface heats the air differently. As we know, colder air is denser, so it makes high pressure; similarly hotter air makes low pressure. So the air’s pressure also varies differently, with place to place, one example is shown at below diagram.
Due to longer day and shorter night, large land masses become hot in summer. Moreover the specific heat capacity of sea is 5 times more than that of land, so land heats the air more quickly than sea. So over large land masses, pressure becomes low in summer. Reversely, land masses become cool in winter, due to short day, with less solar heat and long night. Land becomes cool more easily than sea. So over land, pressure becomes high in winter. For that reason, over large land masses, the pressure is usually high in winter and low in summer.

Atmosphere pressure also changes with the time of the day. It is maximum at about 1000 hrs & 2000 hrs and minimum at about 0400 hrs & 1600 hrs of local time. Since this happens twice in a day, so it is called semi-diurnal variation of atmospheric pressure. The difference of this maximum and minimum values is called semi-diurnal range of atmospheric pressure. It is more in the tropics than in middle latitude and it is negligible at high latitude.

**Doldrums** is an area of low pressure, close to the equator. It is also called as the Inter tropical convergence zone (ITCZ).

In this area, where the average solar radiation is greatest, the air is warmed at the surface and then raised. This creates a band of low air pressure, centered on the equator. Here this rising air is replaced by the winds (is called the Trade winds, shall be discussed on next chapter), coming from north and south. In this area, cumulus clouds are observed, with shower activity. These cumulus clouds are often built up to great heights. Thunderstorms and squalls may experience in this area. Here winds can also be light with hot and sticky weather.

Including above, some more low & high pressure areas of earth, shown at below.
- Polar High (at both poles)
- Sub polar Low. (at about 60° N & 60° S)
- Subtropical High (at about 30° N & 30° S)
- Inter-Tropical Convergence (at equator)
Mean world-wide surface pressure distribution in July.
Here in the warm northern hemisphere, warm areas have low pressure and cool oceanic areas have high pressure.
Mean world-wide surface pressure distribution in January.
In January, except few areas, the pattern becomes more or less reversed, then July.

Mean surface pressure distribution in January, at Bay of Bengal
(Figure -1), Sources: Bay of Bengal Pilot, NP-21
Above figures 1 and 2 are showing the seasonal pattern which determines the regular winter and summer monsoon. Most variations in the run of the isobars occur at the transition periods. The reversal of the pressure gradient between N and S is evident in the monthly values at the coastal stations. The main seasonal change occurs in the N sector of Bay of Bengal; variations in the S are small.
The greater range in the N is due to the influence of the Siberian anticyclone in winter and the deepening of the monsoon low over Pakistan in summer. Both these systems may vary in intensity during each season and from year to year. These deviations affect the strength and regularity of the wind and the seasonal rainfall.

There is a small regular diurnal variation of pressure of between 2 and 3 mbs. The maximum values occur at 1000 and 2200 and the minimum at 0400 and 1600. These changes show up on the barograph in quiet weather but are obscured during disturbed conditions. (Source: Bay of Bengal Pilot, NP-21)

**Contour line** is a line of constant value. If (often just called a "contour") joins points of equal value on a contour map. It has some specific names beginning with "iso-" (a Greek word, meaning 'equal'), according to the nature of the mapping. Definitions of some contour lines are given as below.

**Isobar** is a line of equal or constant pressure, on a graph, plot or map. More accurately, isobars are lines drawn on a map joining places of equal average atmospheric pressure, reduced to sea level for a specified period of time.

Similarly,

**Isostere** is a line of constant atmospheric density.

**Isotherm** is a line of constant temperature.

**Isogeotherm** is a line of equal mean annual temperature.

**Isocheim** is a line of equal mean winter temperature.

**Isothere** is a line of equal mean summer temperature.

**Isohel** is a line of equal or constant solar radiation.

**Isohyet** or isohyetal line is a line of equal precipitation.

**Isohume** is a line of constant relative humidity.

**Isodrosotherm** is a line of equal or constant dew point.

**Isoneph** is a line of equal cloud cover.

**Isochalaz** is a line of constant frequency of hail storms.
An isobar (meaning 'equal weight') is a line of equal or constant barometric pressure on a graph, plot, or map. In meteorology, the barometric pressures shown are reduced to sea level, not the surface pressures at the map locations. The distribution of isobars is closely related to the magnitude and direction of the wind force. They are normally plotted at 4-hPa intervals and clearly illustrate changing pressure. Isobars are varying from 980 to 1012 hPa; can commonly to be found on a single chart. They never cross, but can form relatively concentric curves

The direction of the wind is more or less along the isobars, although sometimes it points slightly inwards towards the nearest low pressure. In the northern hemisphere the wind blows anti clockwise around a low pressure and clockwise around a high pressure. In the southern hemisphere, this is reversed. This wind direction shall be discussed on third chapter.

![Isobar Diagram]

Low pressure (also called a depression or cyclone) is an area where the pressure is lower than that of surrounding stations. It is an area of relatively low pressure with the lowest pressure at the center. In the weather chart & map, low pressure is indicated with “L”.

Wherever pressure is lower, then the normal, depression occurs. The lower the central pressure, the stronger the depression. When the central pressure is falling, this low is said to be deepening. When the reverse occurs and the lowest pressure is increasing, then we say that the low is filling. Among the largest and most devastating depressions, hurricanes are most common, known as typhoons.
in Asia, which can generate surface winds of 64 knots or more. In addition to these strong winds, lows can generate heavy precipitation.

Here wind direction is anti-clockwise at Northern Hemisphere, which is nearly in line with isobar with 10° to 20° angle towards depression. Isobars change direction sharply, when a front is formed.

**Secondary low** is a smaller size of low pressure, which forms within the area, dominated by the main depression. Main low pressure is called primary low and next one is called secondary low, as it forms later, but both have almost same characteristics.

**Trough of low pressure** is a U-shaped elongated area of lower pressure, with higher pressure on either side. It is also applied to the V-shape formed isobars, created during sharp bending or kinking of the isobars, along a frontal depression.

This trough is a curved line of minimum pressure, which can extend over several miles. Phenomenon associated with the trough is the sudden change in the direction of the wind, called a wind shift.

**Col** is a neutral region between two highs and two lows.

Weather conditions are unsettled; generally speaking, cols may be regarded as regions of unreliable weather. In winter, the mixing of air of dissimilar air masses frequently produces fog. In summer, showers or thunderstorms may occur.

**High or anti-cyclone high** is an area of relatively higher pressure, with the highest pressure in the center and decreasing towards the outside. In the weather chart & map, high pressure is indicated with “H”.

A high or anticyclone is the opposite of a low. In this case, the central area is a zone of maximum high pressure. Isobars are generally wider apart near the centre of a high, than near the centre of a low. Here pressure can sometimes exceed 1040 hPa. A high weakens, when its central pressure falls. Fine weather is generally associated with highs.

Anticyclones are much larger than depressions or cyclone and can lead to many days or weeks, with developed and calm weather. Weather conditions can vary between summer and winter anticyclones.

**Summer Anticyclones**

Hot days, with few or no clouds.
Winds are light.

Ground cooling makes morning mist.

Warm moist air rising from the ground can form thunderstorms.

**Winter Anticyclones**

Skies are cloudless.

Less radiation, due to sun’s declination.

Temperature drops, days are cold and nights are colder.

Fog and frost are forming at night.

**Ridge of high pressure** is an elongated area of high pressure, with lower pressure lying on either side.

A ridge or wedge of high pressure is the opposite of a trough. They are generally found in the wake of highs. A high may be surrounded by several ridges, with isobars generally more rounded than those of troughs.

**Pressure Gradient**

The expression "pressure gradient," or simply "gradient," is a horizontal difference in pressure, over a specific distance, measured at right angles to isobars.
It is simply the ratio of the difference in pressure between two points, to the distance between them. The closer the isobars, the stronger the gradient.

The pressure gradient at mean sea level can also be calculated directly on the weather map, since isobars represent the pressure pattern at this level.

**Barometric Tendency** (Also called as barometric tendency) is the local rate of change in surface pressure, which is used to indicate how pressure systems, especially depressions, are moving and developing, which is required for weather forecasters. It is shown on a weather chart marked by isallobars (Lines of constant pressure change are called isallobars).

The barograph makes a permanent recording of barometric variations. As a low approaches, for example, the barograph records a regular drop in pressure. Once the centre of the low has passed, the pressure begins to rise again. These variations are called the barometric tendency or pressure tendency. This tendency normally measures for last three hours of observations.

Simply, it is the difference between the atmosphere pressure at any time and the atmosphere of three hours earlier. When the barograph is not working, then barometric tendency can be measured by the aneroid barometer, by using a fixed pointer on the dial.

**Characteristic of the barometric tendency** is used, as a term, in the weather code, to indicate the shape of the trace on the barograph, during last three hours of observation.

In the “ship’s weather code group”, in 5appp,

‘a’ stands for the characteristic of barometric tendency, during the three hours preceding the time of observation.

‘ppp’ stands for the amount of barometric tendency (i.e. net change in barometer reading) during the three hours preceding the time of observation, expressed in tenths of a millibar.

Weather (cloud, visibility, precipitation etc) is mainly affected by the pressure system. Barograph records the pressure and pressure tendency, which assists onboard officers to determine the movement of the various pressure system, as the pressure usually falls well in advance of a depression and rises in advance of an anti-cyclone.

**Synoptic chart** is a weather chart, reflecting the state of the atmosphere over a large area at a given moment. It generally refers to regional or larger-scale
meteorology of high and low pressure systems, with covering range from several hundred to a thousand kilometers. It shows the distribution of sea-level pressure (i.e. highs, lows, ridge, trough, fronts etc) Synoptic weather maps normally have a diagram, from which geostrophic wind speed can be determined by measuring the distance between successive isobars.

Prognostic chart is a chart, showing the predicted state of the atmosphere for a given time in the future. Basically it is a forecast model chart or display with expected pattern for pressure, temperature, moisture, precipitation etc over a given area, at a specified future time. These displays are based on computer analyses and related physical conditions for future behavior of the atmosphere.